ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

Prepared for:

ASARCO LLC
P.O. Box 1230
East Helena, MT 59635

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

February 2008

ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

Prepared for:

ASARCO LLC
P.O. Box 1230
East Helena, MT 59635

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

February 2008

TABLE OF CONTENTS

LIST OF TABLES iv

LIST OF FIGURES v

LIST OF APPENDICES vi

1.0 INTRODUCTION 1-1

1.1 PROJECT GUIDANCE 1-6

1.2 SITE BACKGROUND 1-7

1.3 COVER SYSTEM BOUNDARY 1-7

2.0 PERFORMANCE STANDARDS 2-1

2.1 GRADE SITE TO PROMOTE DRAINAGE 2-1

2.2 REMOVE CONTAMINATED SOILS TO EPA'S CLEANUP GOALS FOR UNDEVELOPED LANDS 2-2

2.3 COVER THE SLAG PILE 2-3

2.4 COVER THE MAIN PLANT FACILITY AREA 2-4

2.5 CONSTRUCT STORM WATER OUTFALLS 2-5

2.5.1 Design Flows 2-5

2.5.2 Water Quality 2-5

2.5.3 Storm Water Controls 2-6

2.6 ARMOR SLAG PILE ADJACENT TO PRICKLY PEAR CREEK 2-6

2.7 IMPLEMENT THE SEP FOR LOWER LAKE 2-6

2.8 IMPLEMENT SITE SECURITY AND MAINTENANCE 2-7

2.9 SUMMARY OF PERFORMANCE STANDARDS 2-7

3.0 SOIL AND SLAG CONTAINMENT 3-1

3.1 SETTLEMENT 3-1

3.2 GAS GENERATION 3-4

4.0 COVER SYSTEM 4-1

4.1 MULTI-LAYERED COVER SYSTEM 4-1

4.1.1 Hydraulic Barrier 4-1

4.1.2 Drainage Layer 4-3

4.1.3 Protective Layer 4-4

4.1.4 Anchor System....................4-4
4.2 EVAPOTRANSPIRATION COVER FOR SLAG PILE....................4-10
4.3 SOIL REMOVAL AREA....................4-10
4.4 MONITORING WELL EXTENSIONS....................4-13
5.0 STORM WATER SYSTEM....................5-1
5.1 PROPOSED STORM WATER MANAGEMENT SYSTEM....................5-1
5.2 STORM WATER HYDROLOGY....................5-1
5.2.1 Precipitation....................5-2
5.2.2 Drainage Areas....................5-2
5.2.3 Runoff Losses....................5-4
5.2.4 Time of Concentration....................5-4
5.3 STORM WATER RUNOFF ANALYSIS RESULTS....................5-5
5.4 SURFACE RUNOFF MONITORING....................5-6
6.0 STREAMBANK PROTECTION....................6-1
7.0 FLOODPLAIN PROTECTION....................7-1
8.0 SECURITY AND MAINTENANCE....................8-1
8.1 TEMPORARY SITE SECURITY AND MAINTENANCE....................8-1
8.1.1 Housekeeping....................8-1
8.1.2 Routine Inspection and Maintenance....................8-2
8.2 LONG-TERM SITE SECURITY AND MAINTENANCE....................8-3
9.0 2008 COVER SYSTEM CONSTRUCTION....................9-1
10.0 IMPLEMENTATION OF THE EAST HELENA SUPPLEMENTAL ENVIRONMENTAL PROJECT....................10-1
10.1 PHASE 1....................10-1
10.1.1 Flow Conveyance Design and Installation....................10-7
10.1.2 Installation Schedule....................10-10
10.2 PHASE 2....................10-10
10.2.1 Earthwork and Shoreline Improvements....................10-10
10.2.2 Revegetation of Shoreline Areas....................10-12
10.3 PHASE 3....................10-14

10.3.1 Earthwork and Upland Improvements 10-14
10.3.2 Revegetation of Upland Areas 10-16
10.3.3 Visual Screen 10-17
11.0 SCHEDULE 11-1
12.0 REFERENCES 12-1

LIST OF TABLES

TABLE 4-1. COMPARISON OF DRAIN LAYER MATERIAL AND SLOPE....... 4-3
TABLE 5-1. SITE HYDROLOGIC CHARACTERISTICS 5-5
TABLE 5-2. STORM WATER RUNOFF QUANTITIES AND RECEIVING WATERS 5-5
TABLE 5-3. SUMMARY OF RUNOFF RESULTS AT EXISTING FACILITY COMPONENTS 5-6
TABLE 6-1. DESIGN SUMMARY OF PROPOSED RIPRAP ARMORING ALONG PRICKLY PEAR CREEK 6-3
TABLE 10-1. ROD STANDARDS FOR LOWER LAKE 10-3
TABLE 10-2. SOIL LEACHATE AND WATER QUALITY DATA - FILL AREA BETWEEN UPPER AND LOWER LAKE 10-4
TABLE 10-3. SOIL ADSORPTION TESTING DATA - FILL AREA BETWEEN UPPER AND LOWER LAKE 10-5
TABLE 10-4. COVERSOIL SUITABILITY CRITERIA 10-12
TABLE 10-5. WETLAND/RIPARIAN HABITATS AND VEGETATION SPECIES OBSERVED IN THE UPPER LAKE AREA, JANUARY 1997 10-13
TABLE 10-6. ADDITIONAL NATIVE PLANT SPECIES PROPOSED FOR ESTABLISHMENT IN UPPER AND LOWER LAKE WETLAND/RIPARIAN HABITATS 10-14
TABLE 10-7. UPLAND HABITAT AND VEGETATION SPECIES OBSERVED IN THE EAST HELENA AREA, 1997 10-16

TABLE 10-8. ADDITIONAL NATIVE PLANT SPECIES PROPOSED FOR UPLAND HABITAT ESTABLISHMENT IN THE AREA BETWEEN UPPER AND LOWER LAKES 10-17

LIST OF FIGURES

FIGURE 1-1. PLANT COVER SYSTEM SITE PLAN 1-5
FIGURE 3-1. SITE WIDE PERMANENT COVER SYSTEM GRADING PLAN 3-2
FIGURE 3-2. METHANE SAMPLING PLAN FOR TEMPORARY CAPS 3-5
FIGURE 4-1. MULTI-LAYERED COVER SYSTEM 4-2
FIGURE 4-2. TYPICAL ANCHOR TRENCH 4-5
FIGURE 4-3. COVER SYSTEM TIE-IN TO EXISTING STORM WATER INLET DETAIL 4-6
FIGURE 4-4. SLAG PILE COVER SYSTEM 4-7
FIGURE 4-5. COVER SYSTEM TERMINATION AT UPPER AND LOWER LAKE 4-8
FIGURE 4-6. SOIL REMOVAL AREA COVER SYSTEM DETAILS 4-9
FIGURE 4-7. ARSENIC SOIL CONCENTRATIONS 4-11
FIGURE 4-8. LEAD SOIL CONCENTRATIONS 4-12
FIGURE 4-9. TYPICAL DETAIL FOR MONITORING WELL EXTENSION 4-14
FIGURE 5-1. SITE STORM WATER PLAN 5-3
FIGURE 6-1. TYPICAL ROADWAY AND RIPRAP DETAIL 6-2
FIGURE 7-1. PRICKLY PEAR CREEK CURRENT 100-YEAR FLOODPLAIN BOUNDARIES AND FLOODWAY 7-2
FIGURE 7-2. PRICKLY PEAR CREEK FLOODPLAIN MODIFICATIONS WITH BRIDGE REMOVED 7-4
FIGURE 7-3. PLAN VIEW OF BRIDGE STRUCTURE TO BE REMOVED 7-5
FIGURE 7-4. SECTION VIEW OF BRIDGE STRUCTURE TO BE REMOVED 7-6

FIGURE 9-1. PROPOSED 2008 PERMANENT COVER SYSTEM GRADING PLAN 9-2
FIGURE 9-2. TEMPORARY COVER SYSTEM TERMINATION 9-3
FIGURE 10-1. RIPARIAN AREA ENHANCEMENTS 10-2
FIGURE 10-2. SIMULATED ARSENIC CONTRIBUTION FROM SHALLOW PLANT SITE SOILS 10-6
FIGURE 10-3. WATER QUALITY TRENDS IN LOWER LAKE 10-8
FIGURE 10-4. GENERAL CONVEYANCE DETAIL 10-9
FIGURE 10-5. EARTHWORK AND SHORELINE IMPROVEMENTS ON LOWER LAKE 10-11
FIGURE 10-6. UPLAND AREA ENHANCEMENTS 10-15
FIGURE 11-1. COVER SYSTEM DESIGN SCHEDULE 11-2

LIST OF APPENDICES

APPENDIX A SPECIFICATIONS
APPENDIX B DRAWINGS
APPENDIX C HELP OUTPUT FILES
APPENDIX D EVAPOTRANSPIRATION COVER SYSTEM CALCULATIONS
APPENDIX E RIPRAP DESIGN CALCULATIONS
APPENDIX F FLOODPLAIN ANALYSIS

ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

1.0 INTRODUCTION

On May 5, 1998, ASARCO LLC (Asarco) and the United States Environmental Protection Agency (EPA) entered into a Consent Decree (RCRA Consent Decree, U.S. District Court, 1998) to initiate the corrective action process in accordance with the Resource Conservation and Recovery Act (RCRA) and the Clean Water Act (CWA). As part of the RCRA Consent Decree, Asarco prepared several site investigation documents including:

- RCRA Current Conditions/Release Assessment (CC/RA) (Hydrometrics, 1998)
- Interim Measures Work Plan, East Helena Facility (Hydrometrics, 1999)
- RCRA Facility Investigation (RFI) Work Plan (Hydrometrics, 2000) and
- Phase I RCRA Facility Investigation Report (Asarco Consulting Inc. (ACI) 2003, revised 2005).

A complete listing of RCRA Consent Decree documents is contained in the Phase I RCRA Facility Investigation (RFI) Site Characterization Report (ACI, 2003).

The Phase I RFI report characterized surface soils, subsurface soils, groundwater and surface water on the East Helena Plant site. It identified the presence of arsenic plumes that begin on the plant site and extend into the City of East Helena. It also evaluated the potential for impacts of site soils on groundwater. Based on data presented in the RFI report, elevated levels of arsenic and metals are present at depth in many areas on the plant site and levels remain elevated below the water table in some source area locations.

Since completion of the Phase I RFI report, numerous interim measures have been completed and several supplemental interim measures are expected in 2008 and subsequent years.

Completed interim measures focused on identified source areas and their potential to impact off-site private and public water supplies. Post Phase I RFI interim measures included:

- Augmentation of the existing long-term monitoring program to refine information on the off-site plume and its potential for impacting private and public water supply wells and systems.
- Isolation of identified source areas of contaminants to groundwater by construction of slurry walls and temporary cover systems in the former acid plant sediment drying area and in the former speiss-dross area.

Additional interim measures are expected to address plant site soils and groundwater in 2008 and subsequent years. These measures are expected to include:

- Sampling and selected removal of exposed soil located in the foot prints of demolished structures, that have levels of constituents of concern that are considered elevated compared to existing site wide data. The foot print areas have been and continue to be exposed as a result of cleaning and demolition of site structures, which is being conducted in accordance with a 2007 Administrative Order on Consent between Asarco and the Montana Department of Environmental Quality (MDEQ). This work is described in the plan titled, "2007 Cleaning and Demolition Project, Asarco East Helena Plant" (Hydrometrics, May 2007 and August 2007 Amendment). The proposed program for sampling exposed soil in the foot prints of demolished structures and for remediation of those with elevated levels of constituents of concern is described in the "Demolition Foot Print Exposed Soil Area Sampling Excavation and Confirmatory Sampling Work Plan" (Asarco, 2008). This Soil Sample Work Plan will be submitted separately, but will augment this Cover System Design report.
- Supplemental characterization of on-site and off-site groundwater for elevated concentrations of constituents of concern, particularly arsenic and selenium. This supplemental work includes expansion of the existing monitoring well network and groundwater monitoring program.

- Evaluation of future groundwater interception, treatment and discharge systems to limit off-site migration of arsenic and selenium.

The Phase II RFI will complete the site characterization process. The Phase II RFI will address any remaining characterization of surface and subsurface soils, and groundwater on the site. It will also include a site-specific assessment of human health risks and ecological risks. Based on data and conclusions presented in the Phase I and Phase II RFI reports, a Corrective Measures Study (CMS) will be prepared to evaluate and present the final remedy for the East Helena Site. It is expected many of the interim measures that have been or will be implemented at the East Helena Site will be incorporated as part of the final remedy presented in the CMS.

This Cover System Design Report presents a conceptual design for a site facility cover system for the East Helena plant. This system is presented as an interim action that ultimately will be a part of the final permanent remedy when remaining Consent Decree activities, including the Phase II RFI and the CMS, have been completed, and the final remedy for the site has been selected. Based on data presented in the RFI, soils with elevated metal concentrations appear to be wide spread throughout the plant site area and appear to extend too deep for site-wide treatment or removal to be practical. As a result, a site capping or cover system will be a component of any final remedy that is ultimately implemented for the site.

As noted by EPA: *Cover (or cap) systems at containment sites are used to minimize the infiltration of water into the contaminated material and to serve as protective barriers to isolate contaminants from the public and the environment. EPA encourages flexibility in the design of covers for all waste sites. Covers can range from a simple soil or asphalt layer to protect people from contact with the contaminants, to multi-layered composite caps recommended for more demanding situations. (EPA, 2002)*

Asarco proposes to place a cover system over the East Helena plant site in order to address the environmental issues presented in the "Remedial Investigation and Feasibility Study"

(RI/FS, Hydrometrics, 1990) and the "RCRA Facility Investigation" (RFI, ACI, 2003). When combined with a systematic approach of facility cleaning and structural demolition, the cover system provides permanent site stability and closure. Site elements or media for which environmental concerns may be at least partially addressed by a site cover system include:

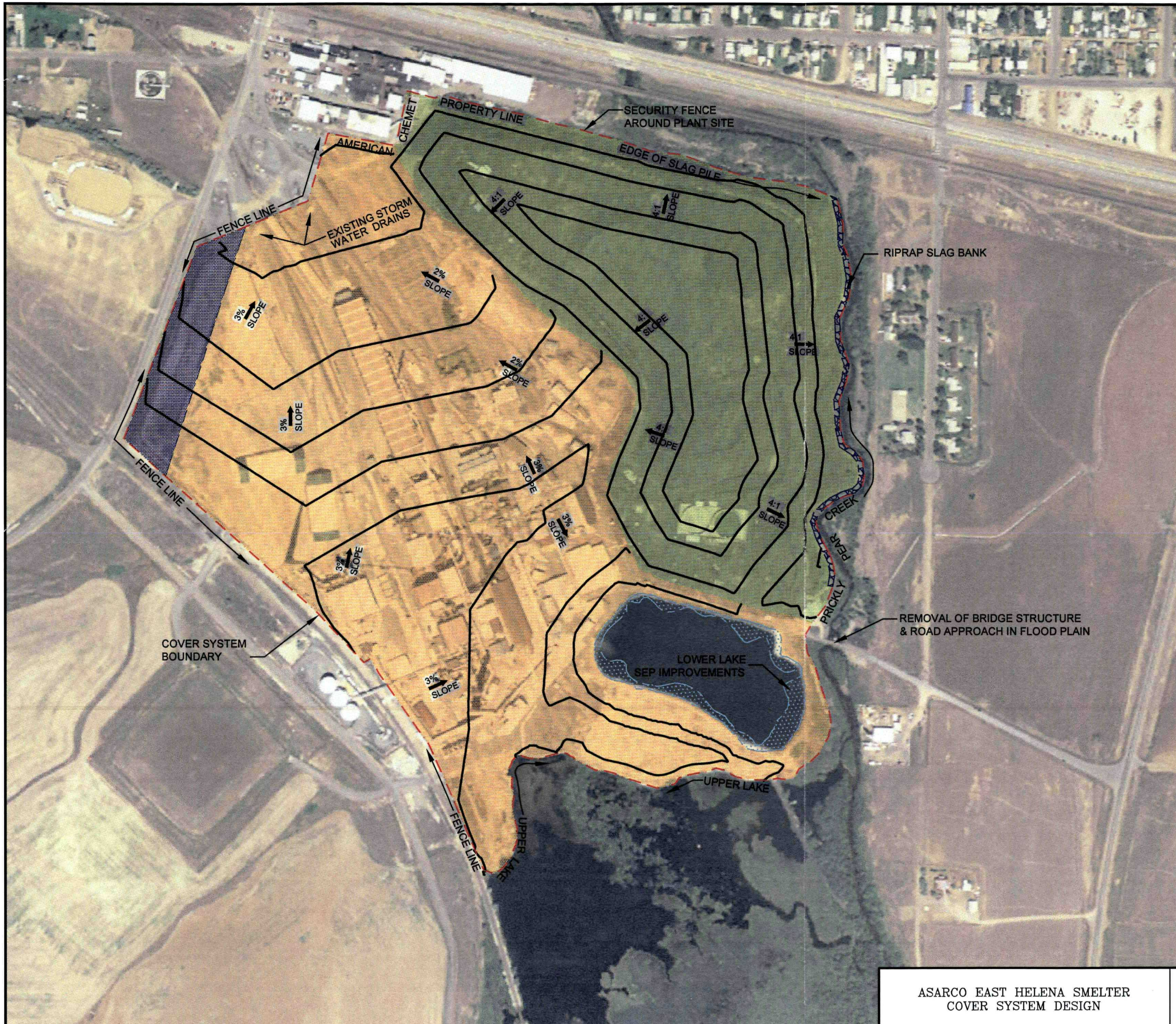
- Groundwater
- Surface water
- Surface and subsurface soil and
- Slag pile.

Although this list includes water, the cover system targets the contribution that site soils and waste products, such as slag, have on the site media listed above. Asarco's goals for the cover system include:

- Minimize the potential for infiltration and contact of facility soils with groundwater and surface water
- Isolate the facility from the public and surrounding environment and
- Minimize the potential for erosion on the facility and the potential for the mobilization of sediment to off-facility areas.

As shown in Figure 1-1, the cover system will include nine (9) primary work elements. These include:

- Grade the site to promote drainage.
- Remove contaminated soils on the west boundary portion of the plant and incorporate under a multi-layered cover system.
- Cover the slag pile.
- Cover the remaining portions of the site where soil removal will not be conducted because complete removal is not feasible or practical.



SCALE

(In Feet)

0 400

NORTH

LEGEND

- PROPOSED LOCATION OF CONTAMINATED SOIL REMOVAL TO ACHIEVE EPA'S PREFERRED CLEANUP ALTERNATIVES.
- PROPOSED SITEWIDE MULTILAYERED COVER SYSTEM
- PROPOSED SLAG PILE EVAPOTRANSPIRATION COVER SYSTEM
- LOWER LAKE SEP IMPROVEMENTS
- 4:1 SLOPE — SLOPE DART - SHOWS DIRECTION OF RUNOFF AND SLOPE ANGLE
- SECURITY FENCE

NOTES:

THE COVER SYSTEM WILL INCLUDE NINE (9) PRIMARY ELEMENTS. THESE INCLUDE:

- GRADE THE SITE TO PROMOTE DRAINAGE.
- REMOVE CONTAMINATED SOILS ON THE WEST BOUNDARY PORTION OF THE PLANT AND INCORPORATE UNDER A PLANT WIDE COVER SYSTEM.
- COVER THE SLAG PILE
- COVER THE REMAINING PORTIONS OF THE SITE WHERE SOIL REMOVAL WILL NOT BE CONDUCTED BECAUSE COMPLETE REMOVAL IS NOT FEASIBLE OR PRACTICAL.
- MODIFY EXISTING STORM WATER STRUCTURES TO CONVEY WATER OFF SITE
- ARMOR PRICKLY PEAR CREEK
- IMPLEMENT THE SUPPLEMENTAL ENVIRONMENTAL PROJECT (SEP) FOR LOWER LAKE
- REMOVE THE EAST BRIDGE AND ASSOCIATED FLOODPLAIN ENCROACHMENTS AND
- SECURE THE SITE

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	PLANT COVER SYSTEM SITE PLAN	FIGURE 1-1

UPDATE TIME: 10:22AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H002.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

- Modify existing storm water structures to convey water off site.
- Armor Prickly Pear Creek.
- Implement the Supplemental Environmental Project (SEP) for Lower Lake.
- Remove the east bridge and associated floodplain encroachments.
- Secure the site.

This document and its appendices contain Asarco's proposal for general design and construction of the cover system, which will be deployed in stages following cleaning and demolition of the East Helena Smelter. It also presents detailed design for construction of a portion of the cover system in 2008 (see Section 9.0). Design of source area excavations, off-site remediation, source area isolation barriers, the proposed reactive barrier, and other groundwater migration controls are not addressed in this document.

1.1 PROJECT GUIDANCE

Three published reports comprise the guidance for this project. These include:

- Comprehensive Remedial Investigation/Feasibility Study (RI/FS, Hydrometrics, 1990)
- Current Conditions Release Assessment (CCRA, Hydrometrics, 1998) and
- RCRA Facility Investigation (ACI, 2003).

The proposed cover system seeks to address specific environmental issues raised in these reports, as well as incorporate EPA guidance for RCRA cover systems, including:

- Reusing Superfund Sites, Commercial Use Where Waste is Left in Place, 2002
- Design and Construction of RCRA/CERCLA Final Covers, May, 1991
- Design, Construction, and Maintenance of Cover Systems for Hazardous Waste, and Engineering Guidance Document, November, 1987 and
- Evaluating Cover Systems for Solid and Hazardous Waste, September 1982.

1.2 SITE BACKGROUND

The Asarco East Helena Smelter site has been described in detail in the RI/FS, CCRA, and the RCRA Facility Investigation. This report will not repeat information that has already been submitted in these other reports, but will seek to summarize performance standards that the design must meet and to explain how each element of the proposed project supports the objectives of these previous works.

1.3 COVER SYSTEM BOUNDARY

Figure 1-1 shows the extent of the cover system that Asarco is proposing for the site. From the corner of the Asarco plant nearest American Chemet property, the cover system boundary follows the fence line around the south side of the plant to Upper Lake, where it follows the edge of Upper Lake until it reaches the east end of the disturbed area between Upper Lake and Lower Lake, referred to as Tito Park. In order to allow enough depth above the water table to construct the cover system layers and anchor the liner(s) in a trench, the boundary will be kept back from the pond edges a sufficient distance to place the cover system surface at an elevation approximately 4 feet above the lake levels. After crossing Tito Park, the proposed boundary extends on around the east side of Lower Lake until it intersects Prickly Pear Creek. The boundary will follow the west bank of the creek to the north and then the west, encompassing two sides of the slag pile. Where the creek flows under Highway 12 on the north side of the plant, the boundary will follow American Chemet's property line back to the plant fence and its starting point in this discussion.

Although most the area within this boundary will receive a cover, there is a portion within the boundary along the west side of the plant where it may be practical to remove contaminated surface soils as part of the grading needed to promote good site drainage. We anticipate that the depth of cut in this area may result in soils that are clean enough to meet remediation standards and not require the cover. These standards are yet to be determined, but for the purposes of this document, EPA's cleanup goals for underdeveloped land for commercial/industrial use in the East Helena area have been assumed. This area is shown in purple on Figure 1-1. Therefore, the project boundary may vary from the cover system boundary in this area.

2.0 PERFORMANCE STANDARDS

As stated in Section 1.0, cover systems at containment sites are used to minimize the infiltration of water into the contaminated material and to serve as protective barriers to isolate contaminants from the public and the environment (EPA, 2002). More specifically, the proposed cover system is designed to:

1. Prevent direct contact of people, animals, and surface water with contaminated soils and slag.
2. Prevent contaminated soil and slag from being wind-blown.
3. Minimize water infiltration.
4. Function with minimum maintenance.
5. Promote drainage while guarding against erosion or abrasion of the cover.
6. Minimize settling and subsidence so that the cover's integrity is maintained.

The following Performance Standards are parameters by which the success of design and construction of the cover system for the East Helena Plant can be measured. They contain criteria that must be satisfied to achieve the remediation goals set for each project element. The project guidance documents were reviewed for relevant project standards. Performance standards were identified from guidance documents for each of the cover system project elements.

2.1 GRADE SITE TO PROMOTE DRAINAGE

One of the goals of the cover system is to minimize the infiltration of water into the contaminated material. In order to accomplish this goal, Asarco proposes to grade the site to promote drainage and prevent surface water from pooling. EPA recommends that the final surface of soil be graded at a slope between three and five percent (EPA, 1991). Any liners used in construction of the cover system should also be constructed with sufficient slope to promote drainage and keep the depth of water that pools on their surface to a minimum. EPA recommends a minimum slope of three percent for liners (EPA, 1991). However, there are a few areas on the site where a grade slope of three percent is not achievable without placement of a significant depth of fill.

Deep fill areas are not desirable because of the increased risk of settlement under the cover system. Settlement can put stress on liners and create low areas where water will pool despite the slope. Therefore, Asarco proposes the following performance standard:

- Limit depths of fill beneath the cap to 10 feet.
- Use a minimum slope of three percent for site grading except where this slope would result in fill areas that exceed 10 feet.

Use of a geosynthetic drainage layer above the cover system liner will compensate for some degree of reduction in slope by providing better drainage above the liner than if a sand drain were used, as recommended by EPA (1991). Therefore, Asarco proposes the following performance standard:

- In areas where the target slope of three percent will result in depth of fill exceeding 10 feet, establish a minimum slope of one percent as the performance standard for grading.

When used with both a geosynthetic liner and drainage layer, modeling of the flow from the drainage layer with a minimum slope of one percent was found to remove nearly as much water as with a three percent slope and effectively reduced the depth of ponding on the underlying liner. Further discussion of the drainage layer, including modeling results is presented in Section 4.1.2.

2.2 REMOVE CONTAMINATED SOILS TO EPA'S CLEANUP GOALS FOR UNDEVELOPED LANDS

To achieve performance standards for site grading and drainage, there may be areas near the cover system boundary where surface soils will need to be excavated. Surface soils in these areas will be removed to achieve the cleanup goals for undeveloped lands for commercial/industrial use set forth in EPA's Proposed Plan for residential areas and undeveloped lands within the East Helena Superfund site (EPA, 2007). Areas of the plant that achieve EPA's cleanup goals through soils excavation and removal will not be included under the cover system. EPA's preferred cleanup goals for undeveloped land for commercial/industrial use include:

- Lead – where soil lead concentrations exceed 1300 mg/kg, soils will be excavated until all remaining lead concentrations, after excavation, are less that 1300 mg/kg.
- Arsenic – where soil lead concentrations exceed 270 mg/kg, soils will be excavated until all remaining lead concentrations, after excavation, are less that 270 mg/kg.

Figure 1-1 suggests an area of the site, shown in purple, where this performance standard may be applicable. Soils removed from these areas will be incorporated as fill under the multi-layered cover system.

2.3 COVER THE SLAG PILE

The effect of the slag pile on groundwater and surface water was evaluated as part of the 1990 Comprehensive RI/FS. Based on the results of the evaluation, the RI/FS concluded that the potential for impacts to groundwater and surface water from slag is low. The reasons for this conclusion was the fact that measured infiltration into the slag pile was very low, and tested leachate showed a low potential for metals mobility from slag. The EPA did not issue a CERCLA Record Of Decision (ROD) that addressed the slag pile, and as a result specific remedial action for this feature has not been specified.

However, recent groundwater data collected in fall 2007 suggest a source of elevated selenium concentrations in groundwater beneath the slag pile. Although recent data also show the slag collected from surface locations have low metal concentrations and low leachate potential for selenium, a potential source of selenium at the base of the slag or immediately below the slag pile is suggested by the fall 2007 groundwater quality data. Similar to plant site soils, the potential source of selenium under the slag pile is too deep for removal methods to be practical, and Asarco and EPA are evaluating control of selenium migration by groundwater control and/or treatment methods. Although a final remedy has yet to be determined in accordance with the Consent Decree process, it is expected capping of the slag pile as an interim measure will be incorporated into the final remedy. Therefore, Asarco proposes these performance standards for the slag pile cover system:

- Prevent direct contact of people and animals with slag.
- Minimize the potential for infiltration of water through the slag pile.
- Prevent slag from being wind-blown and eroded.
- Stabilize slag pile.

An Evapotranspiration (ET) cover system is proposed for the area of the plant site shown in green on Figure 1-1. Asarco proposes the following performance standards for this cover system:

- Provide a 42-inch layer of engineered cover soil and a 6-inch layer of soil capable of sustaining plant species, and a good cover of vegetation that will allow runoff but prevent erosion.

2.4 COVER THE MAIN PLANT FACILITY AREA

For hazardous waste management units, EPA recommends that the final cover consist of, from bottom to top:

1. A low hydraulic conductivity geomembrane or soil layer.
2. A soil or geosynthetic drainage layer.
3. A soil layer with either vegetation or armor.

Therefore, except in areas that can be practically cleaned up to achieve EPA's preferred cleanup alternatives by soil removal and the slag pile, Asarco proposes to place a multi-layered cover system, similar to the one on Asarco's Corrective Action Management Unit

(CAMU, Hydrometrics, 2007b), over the portion of the site shown in yellow on Figure 1-1. Asarco proposes the following performance standards for this cover system:

- Provide a low hydraulic conductivity layer, covering the soil, concrete and slag, composed of a composite of geosynthetic clay liner on the bottom and an appropriate geomembrane on the top.
- Provide a drainage layer over the liner composed of a geosynthetic drainage net.
- Provide a 36-inch layer of cover soil that includes 6-inches of soil capable of sustaining plant species, and a good cover of vegetation that will allow runoff but prevent erosion.

2.5 CONSTRUCT STORM WATER OUTFALLS

In order to function properly, the cover system drainage layer will need a place to freely discharge. Asarco proposes to use existing storm water system intakes to accept this storm water from the cover system. The existing storm water system will provide a level of collection for storm water until it can be treated in the current water treatment plant. It is anticipated that, following a finite period of time, the storm water from the cover system will eventually meet discharge requirements without any treatment.

2.5.1 Design Flows

Design of the cover system will be based on:

- Runoff volumes and flow rates from at least the 25-year, 24-hour storm event for design of drainage features and
- Rare events up to the 100-year storm for protection of the cap from damage caused by erosion.

2.5.2 Water Quality

Storm water quality shall meet existing discharge standards (ASARCO, 2006).

2.5.3 Storm Water Controls

Until construction of the cover drainage system is complete, storm water on the site will continue to be collected as it is now. In addition, storm water controls will incorporate the substantive requirements of the Montana DEQ Storm Water Construction Guidance document.

2.6 ARMOR SLAG PILE ADJACENT TO PRICKLY PEAR CREEK

There is direct contact and erosion of the slag pile where it forms steep sided banks adjacent to Prickly Pear Creek. As a result, Asarco proposes the following performance standard for this project element:

- Armor the slag pile stream bank to prevent erosion due to flows up to the 100-year flow event in Prickly Pear Creek.

2.7 IMPLEMENT THE SEP FOR LOWER LAKE

Performance Standards for the Lower Lake SEP (Hydrometrics, 1997) include:

- Identify and improve site conditions that have precluded the establishment of vegetation on barren shorelines of Lower Lake and portions of the Upper Lake north and west shorelines.
- Fill portions of the Lower Lake perimeter to form an irregular shoreline to naturalize the site, create riparian habitat for adapted vegetative communities, expand and enhance wildlife habitat, and potentially improve water quality.
- Grade the area between Upper and Lower Lakes to form naturalized topographical contours to enhance upland vegetative and wildlife habitat.
- Plant vegetative screens along portions of north and west Upper Lake perimeter areas and between Upper and Lower Lake to enhance wildlife habitat.

An additional Performance Standard is proposed for implementation of the SEP:

- Establishment of constructed flow corridors through the area between Upper and Lower Lakes to short circuit flow through the fill in this area and directly improve water quality in Lower Lake. The goal of this action is to improve Lower Lake water quality enough to meet CERCLA Standards for this pond established in the 1989 Process Ponds ROD (EPA, 1989).

2.8 IMPLEMENT SITE SECURITY AND MAINTENANCE

To ensure site security and maintenance of the entire cover system and all its components, Asarco proposes the following performance standards:

- Establish a security fence around the perimeter of the cover system.
- Implement a maintenance plan to ensure the integrity of the cover system.

2.9 SUMMARY OF PERFORMANCE STANDARDS

In order to prevent direct contact of people, animals, and surface water with contaminated soils and slag, prevent contaminated soil and slag from being wind-blown, minimize water infiltration, function with minimum maintenance, promote drainage while guarding against erosion or abrasion of the cover, and minimize settling and subsidence so that the cover's integrity is maintained, the following is a summary of Performance Standards that have been used for design of the proposed grading and capping project:

1. Limit depths of fill beneath the cover system to 10 feet.
2. Slope the site to promote drainage.
   a. Use a minimum slope of three percent for site grading except where this slope would result in fill areas that exceed 10 feet.
   b. In areas where the target slope of three percent will result in depth of fill exceeding 10 feet, establish a minimum slope of one percent.
3. Remediate areas of the plant without a cover system where, after soil removal, lead and arsenic concentrations meet EPA's preferred cleanup alternative goals.

4. Prevent direct contact of people and animals with slag and contaminated soils.
5. Prevent slag and contaminated soils from being wind-blown and eroded.
6. Stabilize slag pile.
7. Minimize the potential for infiltration of water through the slag pile by providing a ET cover system that includes:
   a. A 48-inch layer of cover soil that includes 6-inches of soil capable of sustaining plant species, and a good cover of vegetation that will allow runoff but prevent erosion.
8. Other than on the slag pile and in areas where contaminated soil has been removed to EPA's preferred cleanup alternative goals, provide a multilayered cover system that includes:
   a. A low hydraulic conductivity layer composed of a composite of geosynthetic clay liner on the bottom and a geomembrane on the top.
   b. A drainage layer over the liner composed of a geosynthetic drainage net.
   c. A 36-inch layer of engineered cover soil that includes 6-inches of soil capable of sustaining plant species, and a good cover of vegetation that will allow runoff but prevent erosion.
9. Design drainage features based upon runoff volumes and flow rates from at least the 25-year, 24-hour storm event.
10. Protect the cover system from damage from rare events up to the 100-year storm.
11. Meet existing storm water discharge standards.
12. Incorporate the substantive requirements of the Montana DEQ Storm Water Construction Guidance document.
13. Armor the slag pile stream bank to prevent erosion due to flows up to the 100-year flow event in Prickly Pear Creek.
14. Implement the Lower Lake SEP, including:
    a. Identify and improve site conditions that have precluded the establishment of vegetation on barren shorelines of Lower Lake and portions of the Upper Lake north and west shorelines.

b. Fill portions of the Lower Lake perimeter to form an irregular shoreline to naturalize the site, create riparian habitat for adapted vegetative communities, expand and enhance wildlife habitat, and potentially improve water quality.

c. Grade the area between Upper and Lower Lakes to form naturalized topographical contours to enhance upland vegetative and wildlife habitat.

d. Plant vegetative screens along portions of north and west Upper Lake perimeter areas and between Upper and Lower Lake to enhance wildlife habitat.

e. Establish constructed flow corridors through the area between Upper and Lower Lakes to short circuit flow through the fill in this area and directly improve water quality in Lower Lake.

15. Install a fence to secure the site.

16. Establish a program to maintain the cover system.

The following sections describe the proposed site cover project in more detail and how implementation of these performance standards will ensure that the site covering system is protective of human health and safety and of the environment. The protection of human health and the environment will be addressed further in the RFI Phase II risk assessment.

3.0 SOIL AND SLAG CONTAINMENT

The proposed cover design for the site includes engineered containment of soils, concrete, and slag. As part of Montana Administrative Order on Consent, the remaining identified structures on the site will be cleaned and demolished. The demolition debris will be either recycled or placed into the Phase 2 CAMU cell. When complete, the site surface will be composed primarily of soil, slag, and either Portland Cement (PCC) or Asphalt Concrete (AC). As shown in Figure 3-1, the most notable feature that will be left following cleaning and demolition is the 70-foot high slag pile that occupies nearly half the plant site on its north and east sides. Currently, the sides of the slag pile slope at approximately 1.5 to 1 (horizontal:vertical). This slope is too steep to cover with soil and expect the cover system to remain stable. Therefore, these slopes will be pulled back before being covered.

Reducing the side slopes of the slag pile will generate a quantity of slag that will need to be placed under the site cover system. Figure 3-1 shows the proposed grading plan for placement of the excavated slag under the site cover system. As explained in the following sections, the proposed grading plan is designed to provide drainage for the cover system while keeping the thickness of the engineered fill to a minimum. Engineered containment systems generally do not have serious differential or general subsidence, or gas production (EPA, 2002). However, a portion of the site between Upper and Lower Lakes and the plant poses some concern related to general subsidence and gas production.

3.1 SETTLEMENT

The East Helena Plant site has had numerous geotechnical investigations related to facility construction that have shown the site surface and sub-surface to be composed of materials having high bearing strengths that will not be susceptible to subsidence. For instance, in their geotechnical investigation for construction of the Scrubber Water Treatment Facility, GMT Consultants (1991) recorded blow counts of near 100 (per foot), which is the maximum possible, down to a depth of 12 feet. Blow counts exceeding 50 indicate a very dense soil with bearing strengths exceeding 50 tons-per-square-foot (tsf) for cohesionless soils

ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

SITE WIDE PERMANENT COVER SYSTEM
GRADING PLAN

FIGURE
3-1

UPDATE TIME: 10:57AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H004.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

(Hunt, 1984). The graded fill and cover system will place a maximum distributed load of less than one (1) tsf. In most cases, the structures that once occupied the site placed more stress on the underlying soil than the graded fill and cover system will. Therefore, settlement due to the weight of the fill and cover system is not a concern over most of the site. However, there may be some potential for settlement within the layer of slag that is proposed as fill for grading and drainage.

Slag has been used successfully for grading and drainage under temporary covers throughout the site. It is a strong, dense material and may be primarily responsible for the high blow counts recorded at the site. Stabilizing the sides of the slag pile will produce large quantities of slag that will be used as fill on the site to achieve grades that promote drainage from the cover system. However, it will not be possible to specify a compaction goal for the slag in the typical manner used for soil fill. Proctor tests are meaningless for slag, and its relative density will be a continually changing target because the particle size and specific gravity of the material will be continually changing. Therefore, the proposed compaction specifications are performance and not outcome driven. They specify the number of passes, equipment requirements, and lift thickness to be used, but do not specify a required relative density that must be achieved. For this reason, the total depth of fill used to establish grading for the cover system has been kept to a minimum in order to ensure that if settling of the fill occurs, the amount of settlement will not compromise the cover system. The proposed grading results in a maximum depth of fill of just 10 feet, while allowing a slope of three percent to be established for the cover system over most of the site.

As previously noted, the portion of the site between Upper and Lower Lakes and the plant poses some concern related to general subsidence. This area is composed not of slag mixed with native soil like the rest of the site, but of a mixture of random fill that years ago was placed in this locale and that in some places is quite deep. During design of the Spray Dryer facility, the geotechnical investigation found this area to have layers of weak material that may settle under significant loads. Therefore, the grading plan includes little if any fill in this area of the site.

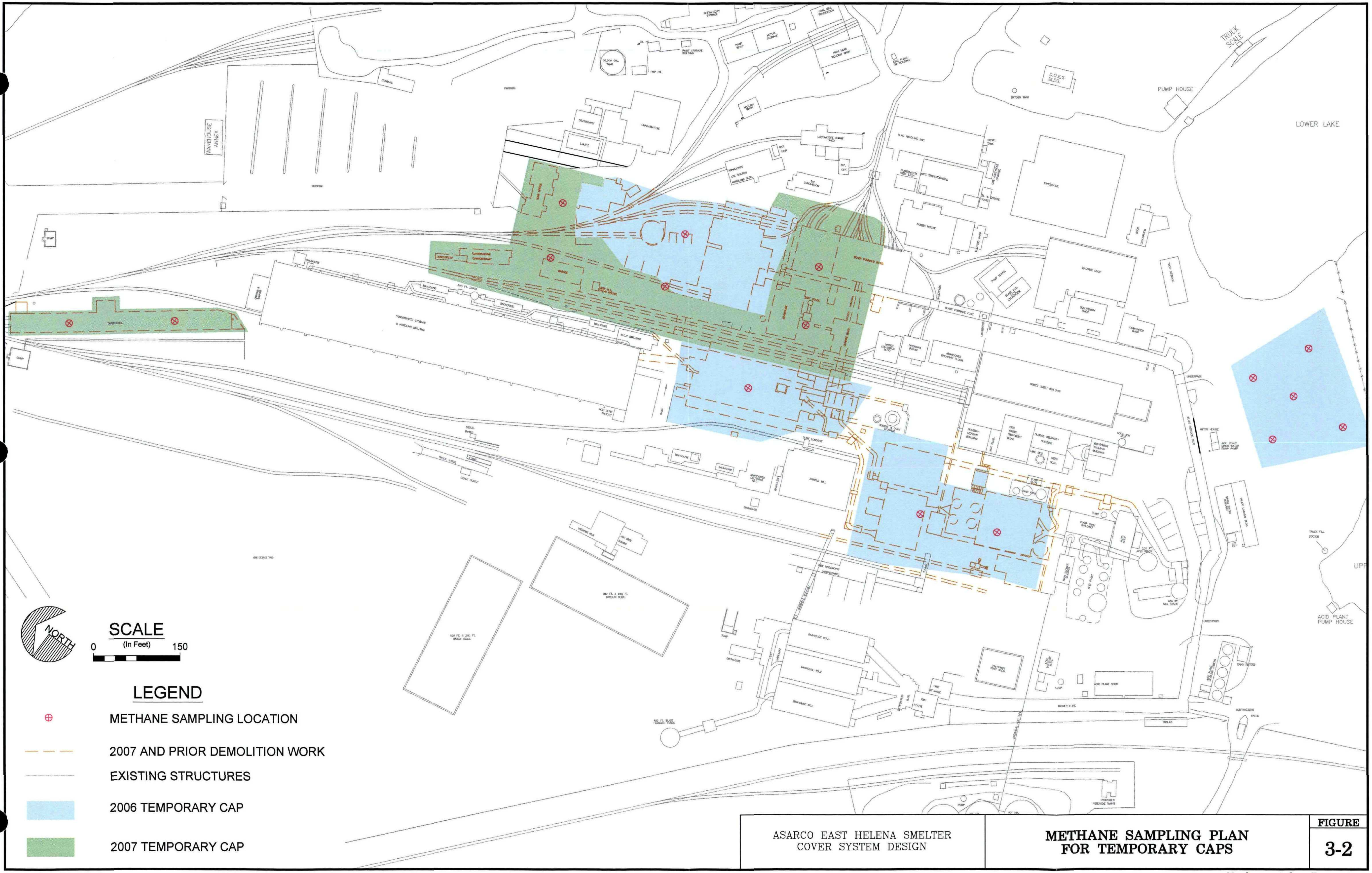
3.2 GAS GENERATION

During 2006 and 2007, Asarco conducted interim remediation actions including the cleaning and demolition of buildings and structures located on the site. After the demolition waste was removed, temporary caps consisting of geomembrane liners were placed over the site to prevent erosion of any potentially contaminated material from wind or rain and to prevent infiltration of water. If any materials remain on the site, such as timbers or wood waste, that could create the potential for production of methane, it would now be collecting under these temporary caps. To ensure that any areas that are actively producing methane receive appropriate consideration during design of the final cover system, an investigation will be conducted for the purpose of determining any areas on the site where methane may be detected beneath the temporary liners. The goals for this investigation include:

1. Determine if methane is present beneath the existing temporary liners
2. Measure and map the level and aerial extent of subsurface methane gas and
3. Repair liner perforations required to sample methane.

To get a general idea of whether methane is being generated below the ground surface and trapped beneath the temporary liner, samples will be collected under every 100,000 square feet of liner as shown in Figure 3-2. Because the area between Upper and Lower Lakes is expected to have a greater potential for methane generation, samples in this area will be collected under every 10,000 square feet of liner. In all, sixteen locations will be sampled for methane, carbon dioxide, oxygen, and nitrogen content.

The gas beneath the liner will be sampled using a portable landfill gas meter. A small slit will be made in the liner with a sharp knife, and the sampling tubing attached to the landfill gas meter will be inserted beneath the liner through the slit. The slit will then be sealed with duct tape to prevent the introduction of atmospheric gases during sampling. After the meter and associated pump are started, the gas readings will be allowed to stabilize before the results are recorded. After sampling, the sample port will be repaired using Griff Tape, an adhesive-backed liner repair sealing tape provided by the liner manufacturer.



ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

METHANE SAMPLING PLAN FOR TEMPORARY CAPS

FIGURE 3-2

JPDATE TIME: 12:05AM
SDP \ HEL\ 020708 \ I:\Land Projects\705402\dwg\ 705402H005.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

Once this data are analyzed, it will define if gas extraction systems are necessary and the extent of gas formation. It may be possible that additional samples may be necessary to better define the nature and extent of volatile gas production.

4.0 COVER SYSTEM

Several cover system types will make up the overall cover system of the facility. The majority of the site, shown in yellow on Figure 1-1, will utilize a multi-layered cover system. The slag pile, shown in green on Figure 1-1, will be covered with an evapotranspiration cover system. An area in the northwest corner of the site, shown in purple on Figure 1-1, will be cleaned up to achieve EPA's preferred cleanup alternative through soil excavation and removal and will be remediated with a vegetative cover.

4.1 MULTI-LAYERED COVER SYSTEM

For hazardous waste management units, EPA recommends that the final cover consist of, from bottom to top:

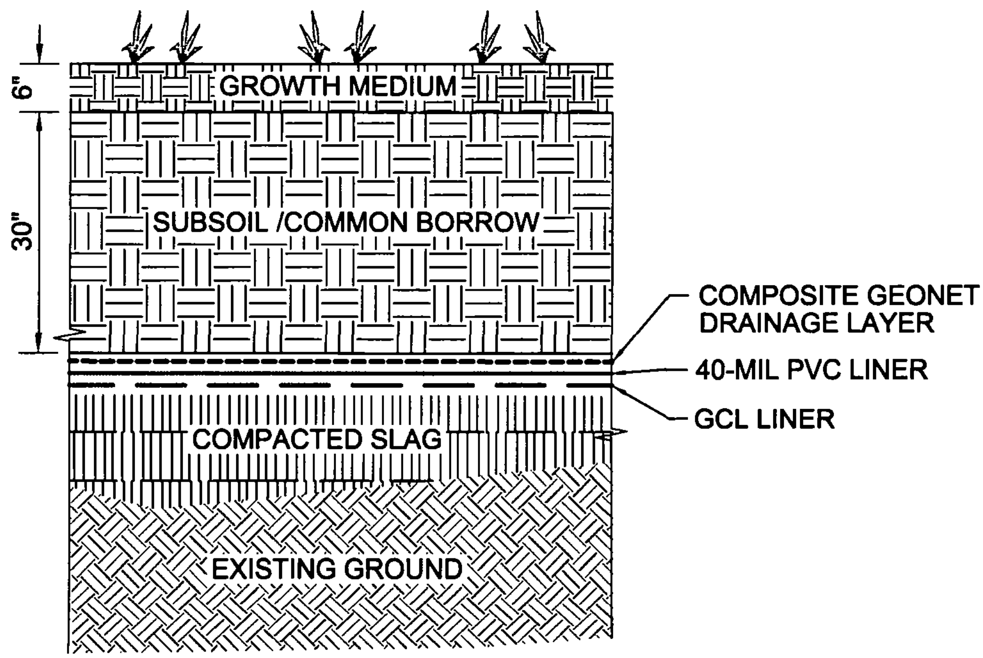
1. A low hydraulic conductivity geomembrane or soil layer.
2. A soil or geosynthetic drainage layer.
3. A soil layer with either vegetation or armor.

As shown in Figure 4-1, from bottom to top the multilayered cover system being proposed for a majority of the site includes a hydraulic barrier covering the slag fill, a drainage layer, cover soil, and erosion protection on the surface.

4.1.1 Hydraulic Barrier

The most common of the three types (hydraulic barriers), use low-permeability material to impede the downward migration of water. They are usually multi-layered cover systems that typically incorporate geomembranes, geosynthetic clay liners, compacted clay liners, or a combination of these as the hydraulic barrier or barrier. (EPA, 2002)

As shown in Figure 4-1, the proposed hydraulic barrier will be constructed of a composite of geosynthetic clay (GCL) and a 40-mil polyvinylchloride (PVC) liner. Placed under the PVC, the GCL liner serves both as the soil portion of the composite liner and as a cushion for the PVC liner. PVC liner is commonly used in the construction of cover systems, due to its ease



ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	**MULTI-LAYERED COVER SYSTEM**	**FIGURE** **4-1**

UPDATE TIME: 10:28AM
JSD\HEL\013008\I:\Land Projects\705402\dwg\705402H008.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

of installation and repair. The 40-mil thickness exceeds EPA's requirement of 30 mils (0.75 millimeter) for hazardous materials containment covers receiving timely cover (Koerner, 1998). This composite liner will minimize infiltration on the site.

4.1.2 Drainage Layer

As shown in Figure 4-1, the proposed drainage layer will be constructed of a composite geonet material and will be part of the cover system wherever a liner is included. The site will be graded so that both the drainage layer and the liner will slope at approximately three percent towards storm water drain inlets to ensure that water collected above the low hydraulic conductivity layers will not pool to any significant depth. The geonet composite will also act as a cushion layer between the PVC liner and cover soil layer.

The proposed composite geonet is functionally equivalent to the recommended drainage layer composed of a minimum of 12-inches of sand with a minimum hydraulic conductivity of 10^{-2} centimeters-per-second (cm/sec) (EPA, 1991). As shown in Table 4-1, performance of the two drainage systems was compared using the Hydrologic Evaluation of Landfill Performance (HELP) Model (EPA, 1994). Results of this analysis suggest that when used with a geonet drain layer, a one percent slope will provide equivalent protection from seepage infiltration as a three percent slope using a soil drainage layer composed of 12-inches of drainage material with a hydraulic conductivity of 1 x 10^{-2} cm/sec (EPA, 1991). HELP model runs for this evaluation are included in Appendix C.

TABLE 4-1. COMPARISON OF DRAIN LAYER MATERIAL AND SLOPE

Drainage Layer Design	Water from Drainage Layer (inches)	Depth of Water on Liner (inches)
12" Sand Drain Layer k = 10^{-2} cm/sec, slope = 3%	0.86	0.18
Geonet Drain Layer T = 6.35 cm^2/sec, slope = 3%	0.85	0.00
Geonet Drain Layer T = 6.35 cm^2/sec, slope = 1%	0.84	0.00

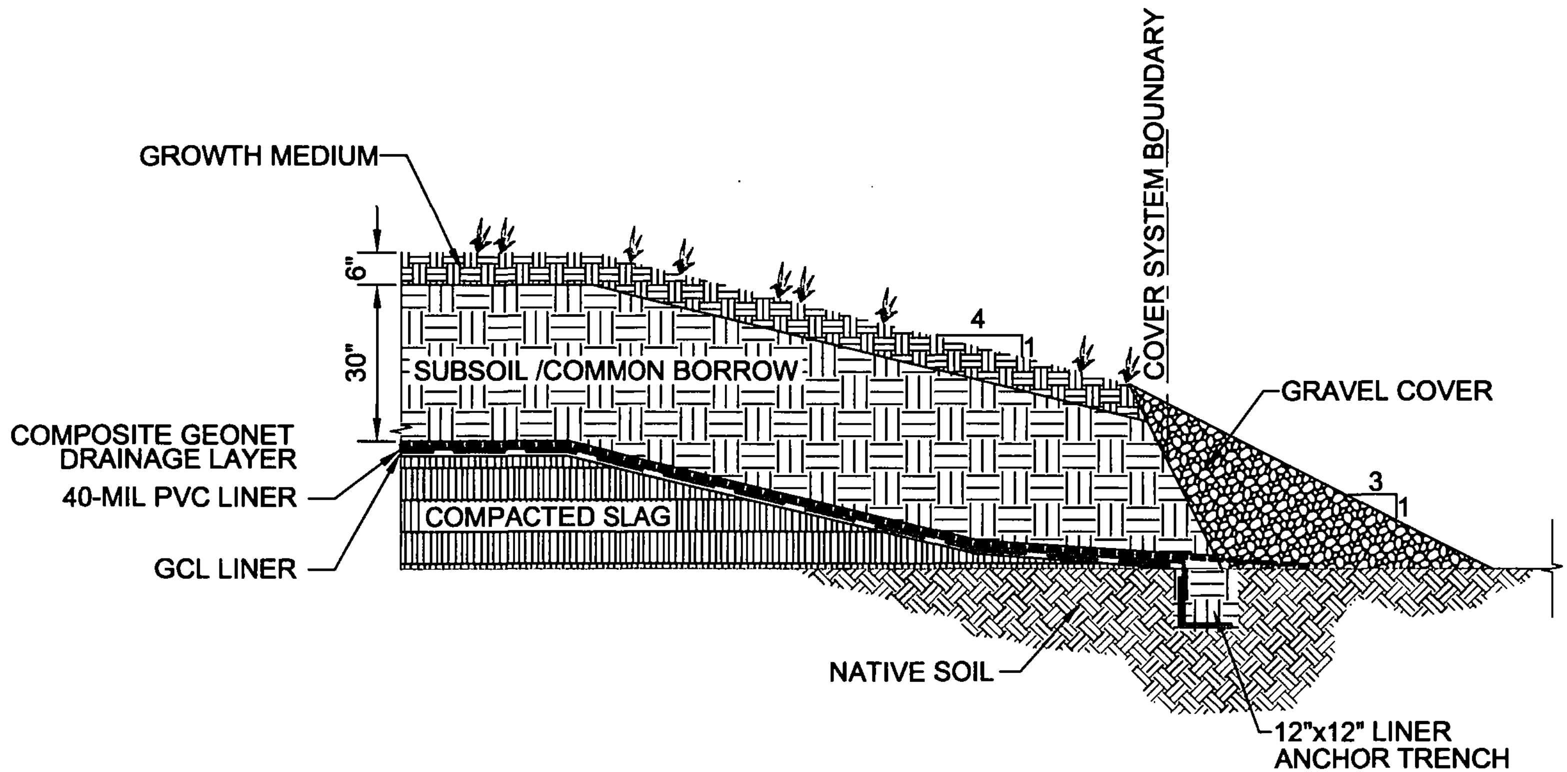
This drainage layer will prevent surface water from infiltrating and coming in contact with contaminated soils and slag and will promote drainage off the liner portion of the cover system.

4.1.3 Protective Layer

As shown in Figure 4-1, erosion protection is provided by a six-inch layer of growth medium for establishing a plant cover of grass. On the portion of the site to receive a liner as part of the cover system, the six-inch layer of growth medium combined with the 30-inch layer of cover soil provides 36-inches of total protection, as in the cover for the CAMU cells.

4.1.4 Anchor System

Around the perimeter of the cover system, the various components of the cover system will terminate and must be protected from erosion and damage. In most areas, the termination will be in soil where construction of an anchor trench with a gravel cover is possible. As shown in Figure 4-2, a typical anchor trench is one foot wide and one foot deep. Once the edges of the liners are placed in the trench, covering at least one side and the bottom of the trench, the trench will be backfilled with a compacted soil and bentonite mix that will securely anchor the liners in place and prevent drainage from the geonet from saturating the trench. As shown in Figure 4-3, in areas of the site where the cover system terminates on pavement, such as at the storm water inlet, stainless steel batten strips will be used to anchor the edges of the two liners to the pavement. The edges of the geonet will be covered with well-draining gravel that will resist erosion while allowing the geonet to freely drain along the edges of the cover system. As shown in Figure 4-4, in areas of the site where the cover system terminates at the slag pile, the typical one foot wide by one foot deep anchor trench will be used. Figure 4-5 shows a typical detail for termination of the multi-layered cover system along Upper and Lower Lakes. Figure 4-6 shows a typical detail for anchoring the multi-layered cover system where it shares a boundary with the soil removal area.

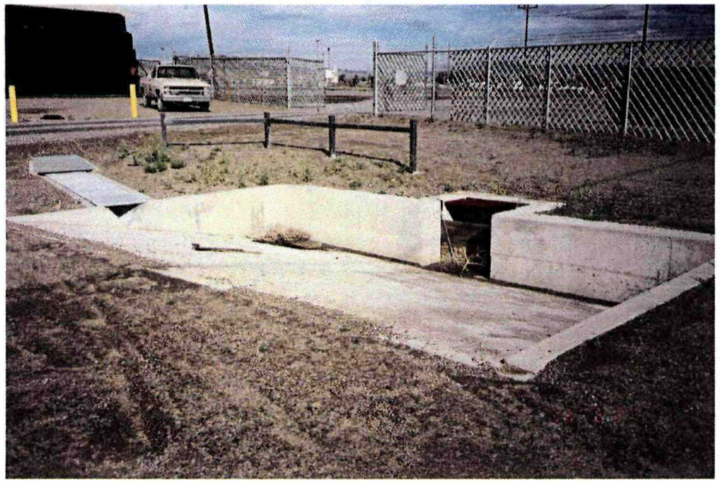


ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

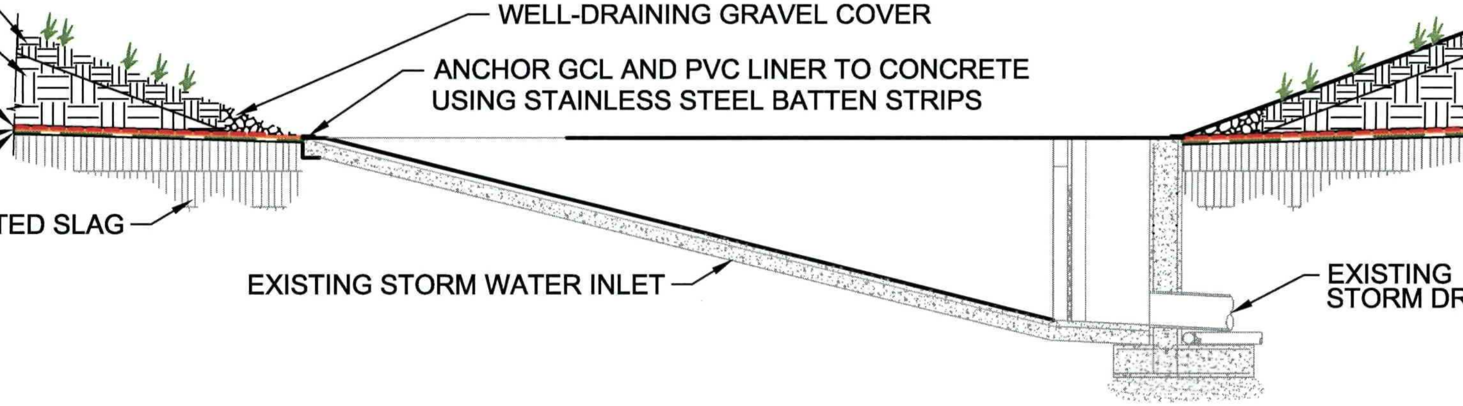
TYPICAL ANCHOR TRENCH

FIGURE 4-2

Hydrometrics, Inc.
Consulting Scientists and Engineers



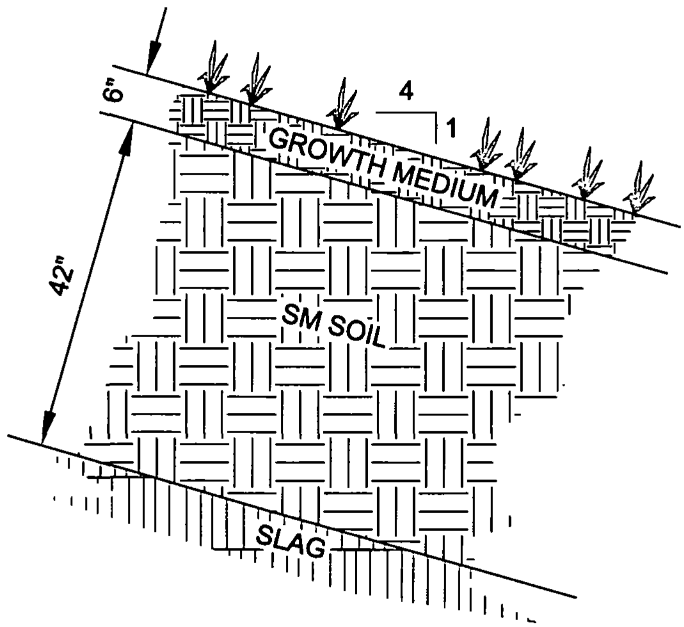
EXISTING STORM WATER INLET



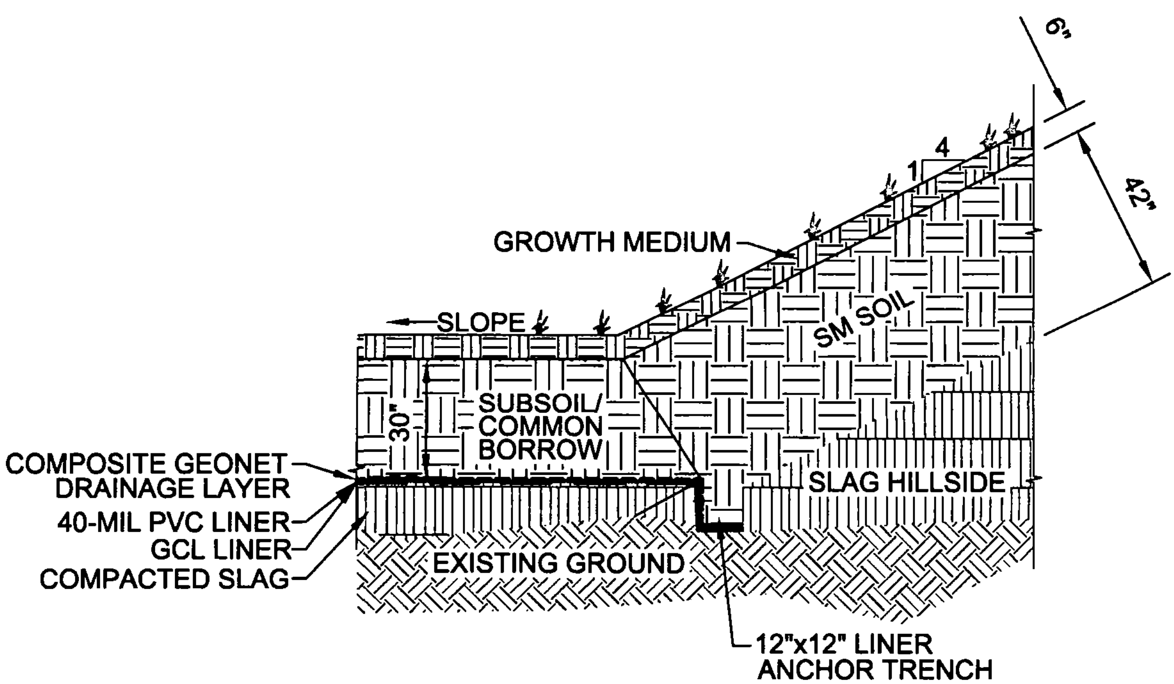
UPDATE TIME: 10:50AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H010.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	**COVER SYSTEM TIE-IN TO EXISTING STORM WATER INLET DETAIL**	**FIGURE** **4-3**

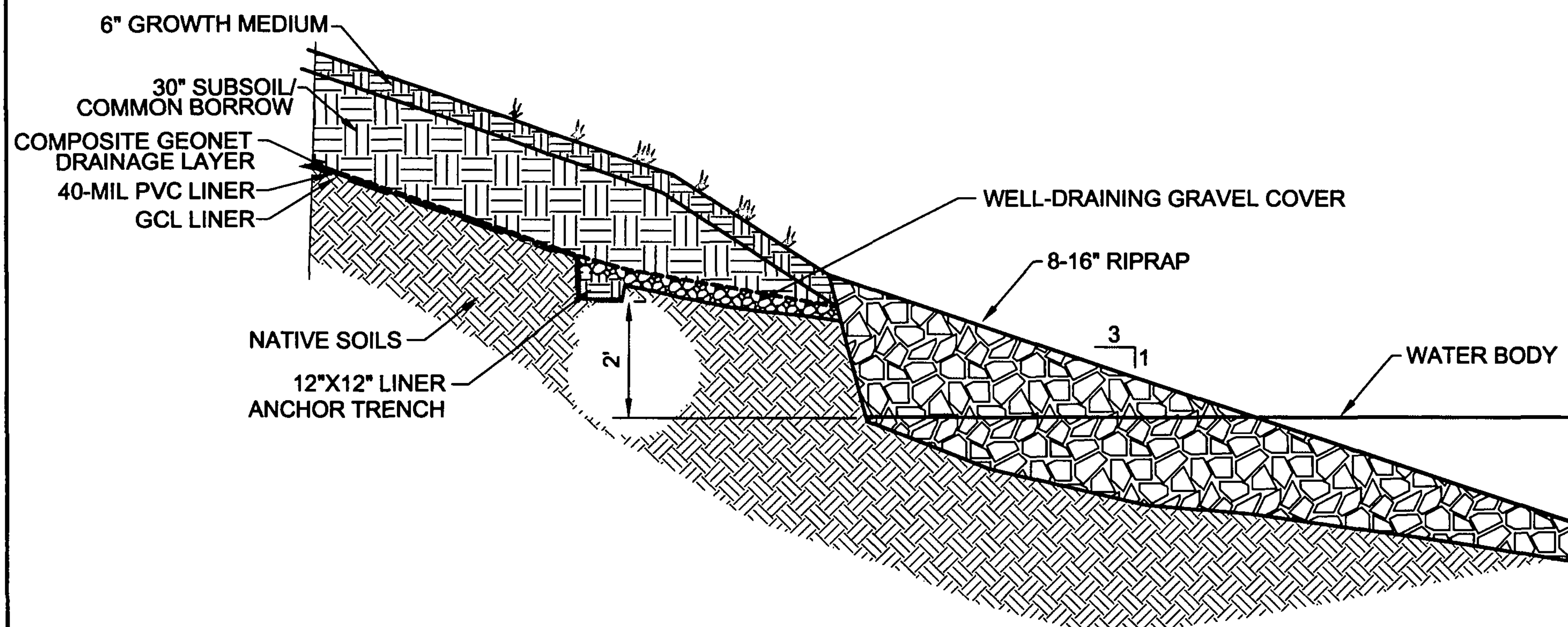


TYPICAL SLAG PILE SOIL E.T. COVER SECTION



TYPICAL COVER TRANSITION AT TOE OF SLAG PILE

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	**SLAG PILE COVER SYSTEM**	**FIGURE** **4-4**



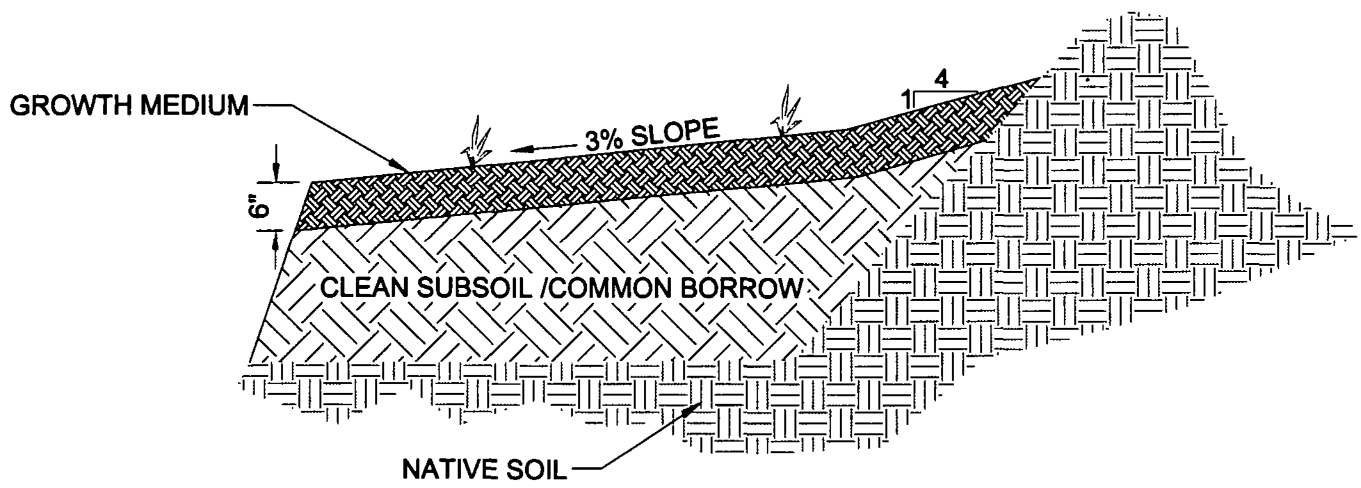
ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

COVER SYSTEM TERMINATION AT UPPER AND LOWER LAKE

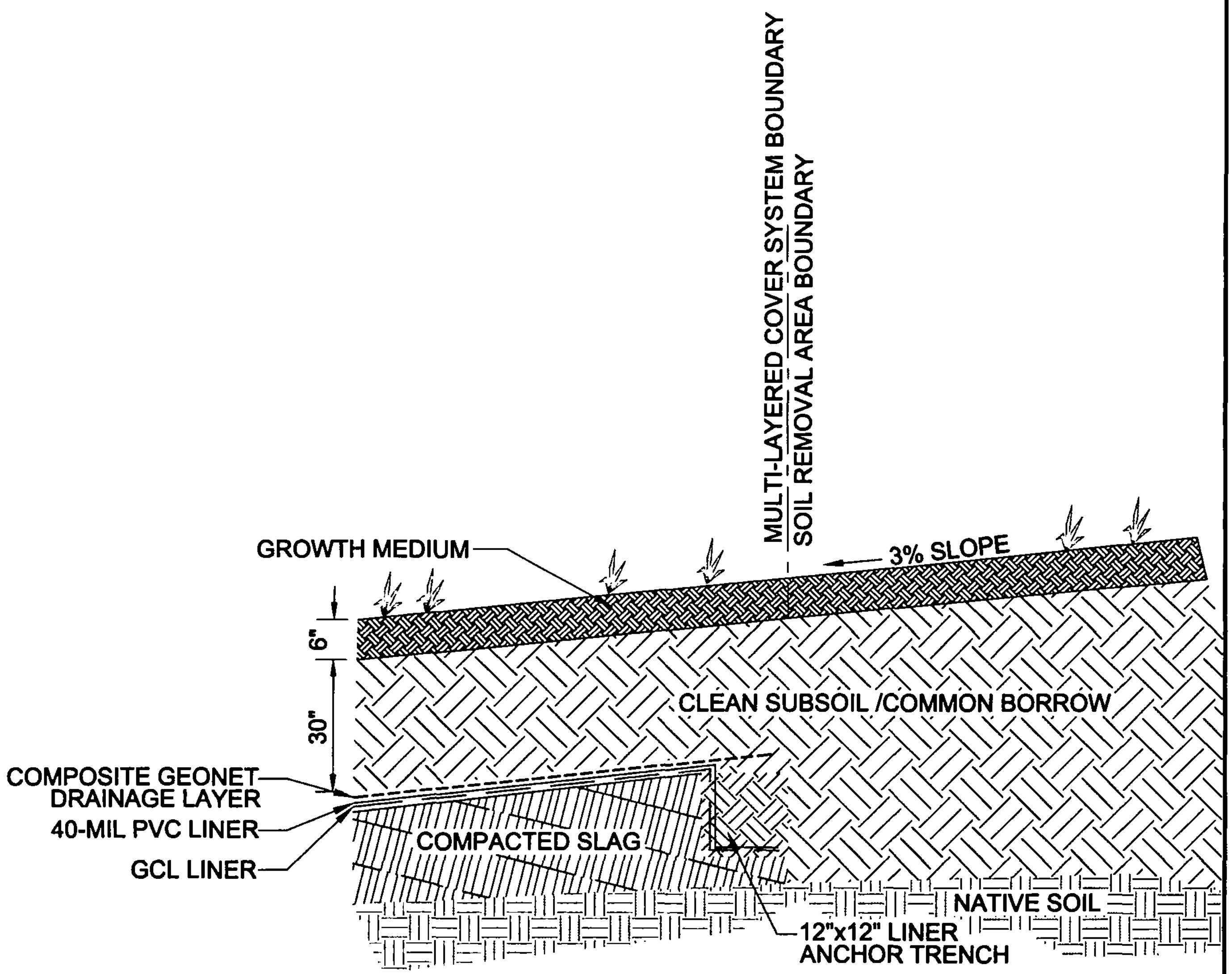
FIGURE **4-5**

UPDATE TIME: 4:53PM
JSD\HEL\020608\I:\Land Projects\705402\dwg\705402H027.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers



TYPICAL CAP BOUNDARY OF SOIL REMOVAL AREA



BOUNDARY OF SOIL REMOVAL AREA AND MULTI-LAYERED CAP

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	**SOIL REMOVAL AREA COVER SYSTEM DETAILS**	FIGURE **4-6**

UPDATE TIME: 1:42PM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H012.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

4.2 EVAPOTRANSPIRATION COVER FOR SLAG PILE

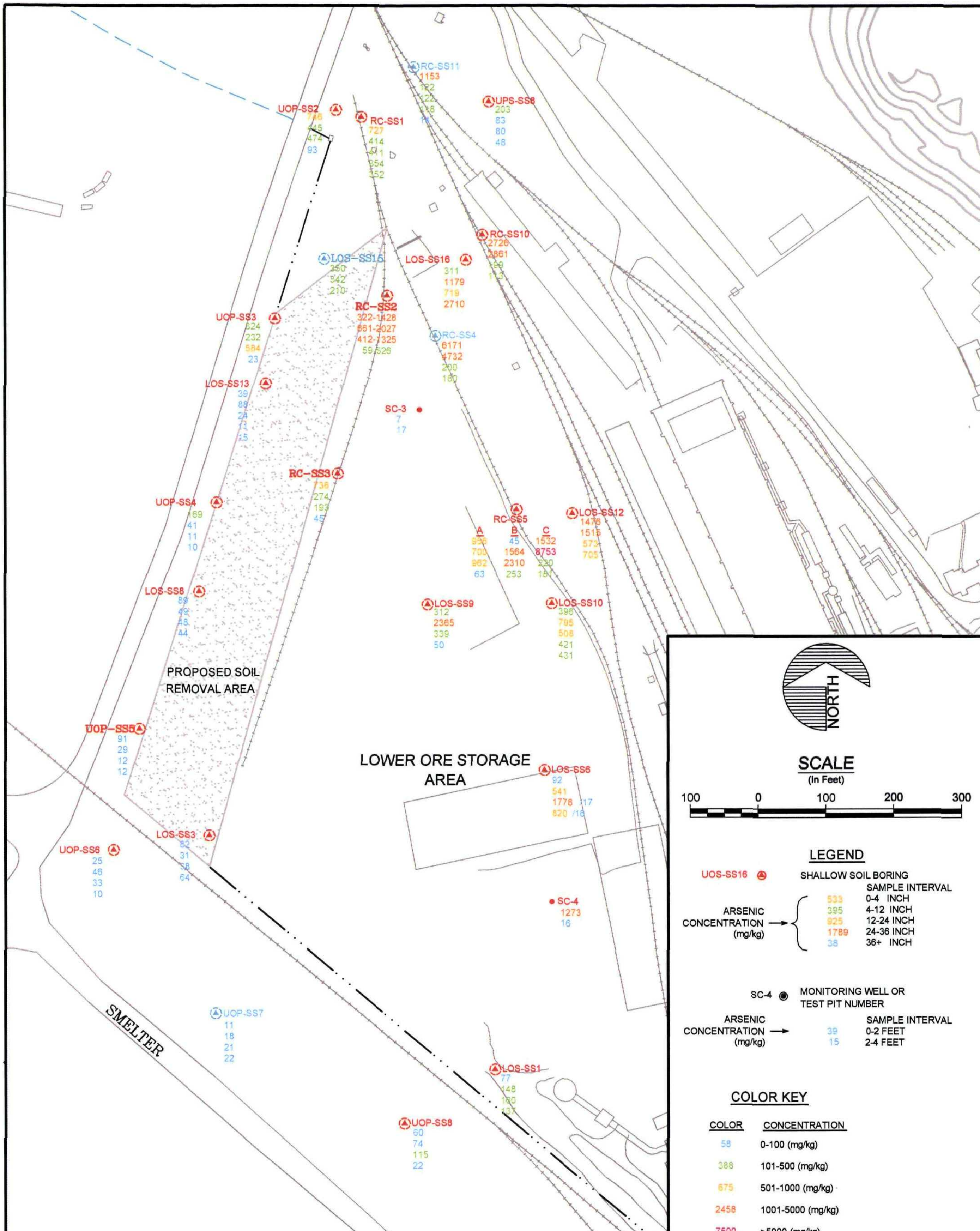
Although the RI/FS concluded that the potential for impacts to groundwater and surface water from slag is low, recent groundwater data collected in fall 2007 suggest a source of elevated selenium concentrations in groundwater beneath the slag pile. To minimize the potential for infiltration of water, the slag pile will be covered with an evapotranspiration (ET) cover system consisting of 42-inches of engineered cover soil (SM soil) and 6-inches of growth medium (Figure 4-4).

The cover soil will consist of sandy silt/clay loam material locally available from nearby Asarco property. The growth medium, also locally available from nearby Asarco property, will be capable of sustaining native plant growth and protecting the cover soil layer from frost effects and rooting damage. The growth medium will be seeded with a mixture of native vegetation designed to provide a variety of rooting depths to facilitate the transpiration of moisture from the cover.

Using conservative estimates of the storage capacity of the soil from the NRCS Soil Survey, precipitation data from the wettest year on record, and evapotranspiration data from the AGRIMET station located in the Helena Valley, calculations show a cover system thickness of 48-inches is adequate to prevent significant infiltration. Preliminary calculations are shown in Appendix D.

4.3 SOIL REMOVAL AREA

As shown in Figure 4-6, the proposed cover system for this area includes 6 inches of growth medium and vegetation to prevent erosion of the soil. Figures 4-7 and 4-8 show the surface concentrations of arsenic and lead respectively in the northwest corner of the site where grading will result in excavation of two or more feet of surface soil in order to get the cover system to drain towards the storm water inlet. The excavated soils removed from this area will be integrated as fill material under the multi-layered cover system. The proposed excavation will remove surface soil in this area. Based on existing site data (see Figures 4-7 and 4-8), average soil arsenic and lead concentrations following soil removal will be



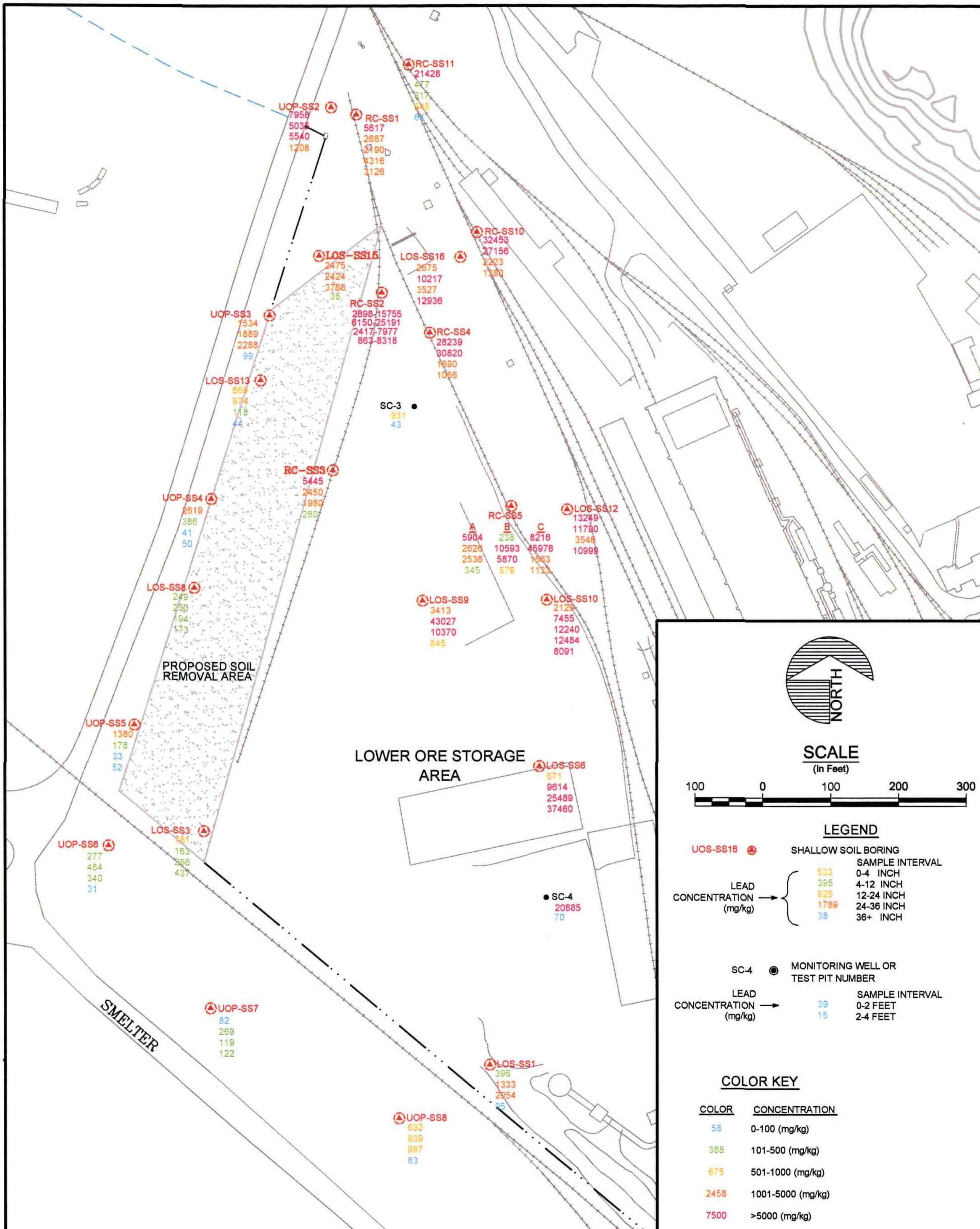
ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

ARSENIC SOIL CONCENTRATIONS

FIGURE **4-7**

UPDATE TIME: 11:41AM
SDP\HEL\020708\I:\Land Projects\705402\dwg\705402H015.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers



ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	**LEAD SOIL CONCENTRATIONS**	**FIGURE 4-8**

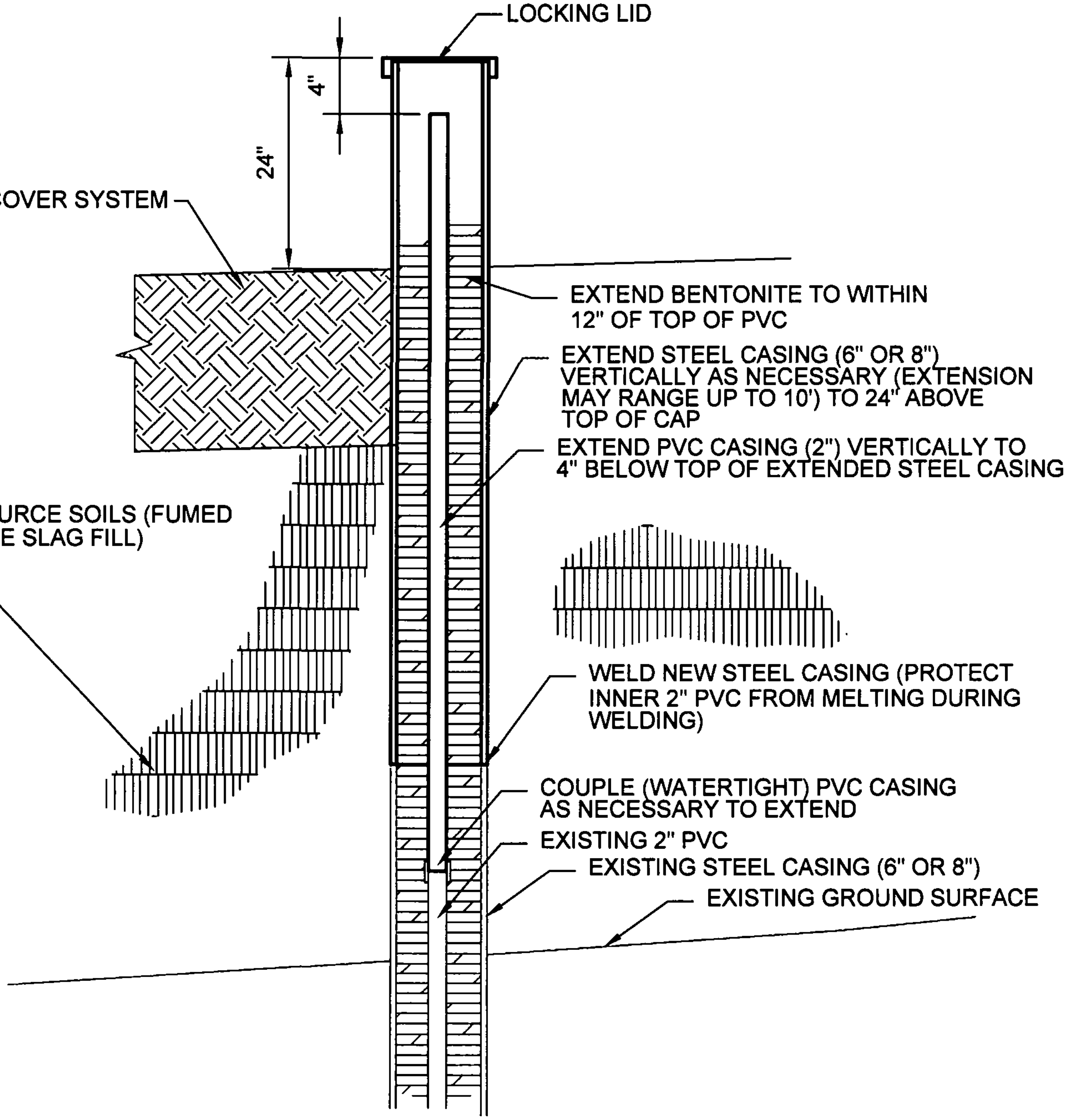
UPDATE TIME: 11:57AM
SDP\HEL\020708\I:\Land Projects\705402\dwg\705402H016.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

28 mg/kg and 143 mg/kg, respectively. This would be significantly lower than EPA's cleanup goals for undeveloped lands for commercial/industrial use of 270 mg/kg for arsenic and 1300 mg/kg for lead. The proposed excavation will similarly reduce other metals concentrations in the remaining soils.

4.4 MONITORING WELL EXTENSIONS

All monitoring wells that will be covered with the final cover system will need to be extended, as shown in Figure 4-9.



NOTE:
MONITORING WELL EXTENSIONS SHALL BE DONE IN ACCORDANCE WITH MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION (MDNRC) MONITORING WELL REGULATIONS AND BY A LICENSED MONITORING WELL CONSTRUCTOR.

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	TYPICAL DETAIL FOR MONITORING WELL EXTENSION	FIGURE 4-9

UPDATE TIME: 12:02AM
SDP\HEL\020708\I:\Land Projects\705402\dwg\705402H026.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

5.0 STORM WATER SYSTEM

Management of storm water to minimize infiltration and erosion on site is integral to the proposed cover system for the East Helena Plant. The existing site will be covered with an engineered fill of slag and soil that will be encapsulated by the cover system. The surface of the fill will be generally graded with a slope towards the north end of the site to promote drainage of the cover system to two existing major storm water inlets located there. The proposed cover system includes storm water management structures to provide for efficient removal of runoff from the capped site and to allow for initial monitoring of storm water quality data for the site. For the short term, existing storm water treatment will remain in place to address water quality concerns for discharges to public surface waters. However, if as expected, the storm water from the covered site meets discharge standards without treatment, the existing water treatment system is expected to be removed at some time in the future.

5.1 PROPOSED STORM WATER MANAGEMENT SYSTEM

Storm water receptors, such as storm drain inlets and conveyances, will need to handle runoff from the 25-year 24-hour design storm. Asarco will utilize the existing storm water management system, described in the East Helena Plant Storm Water Pollution Prevention Plan (ASARCO, 2006) and the Spill Prevention Control and Countermeasure Plan (ASARCO, 2007), to collect the majority of the storm water runoff from the capped area. An analysis was conducted to determine if changes to the existing storm water management system would be needed once the proposed cover system is in place.

5.2 STORM WATER HYDROLOGY

Drainage structures for the covered site were designed for runoff resulting from the 25-year, 24-hour rainfall event, which has a four percent chance of occurrence in any given year. Rainfall losses in the form of infiltration were estimated using the United States Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS) curve number method.

5.2.1 Precipitation

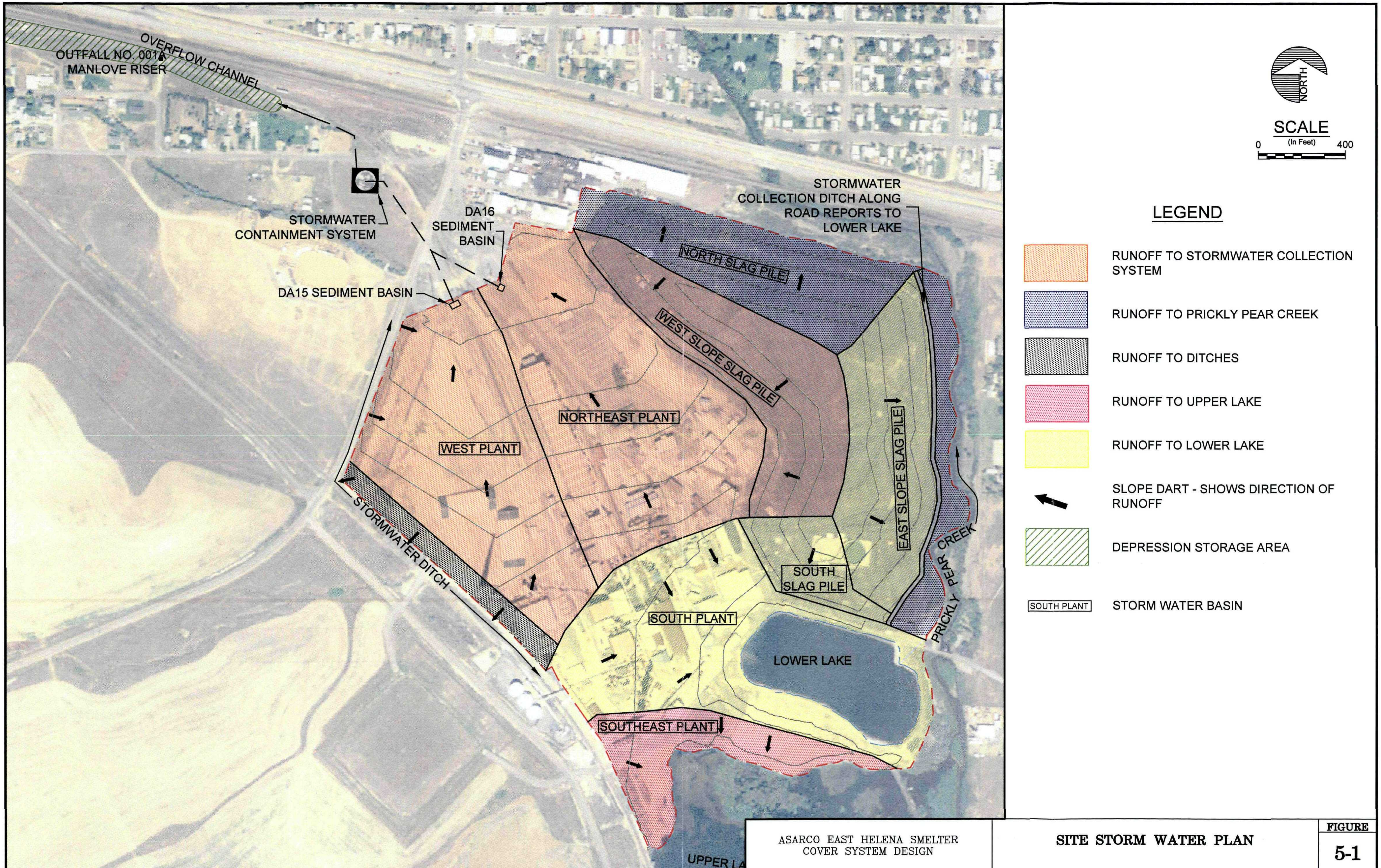
Total rainfall depth for the 25-year, 24-hour storm event was obtained from National Oceanic and Atmospheric Administration (NOAA, 1973) Atlas 2, published by the National Weather Service. Based on the isopluvial contour lines on Figure 28 of NOAA Atlas 2, total precipitation depth for the design storm is 2.3 inches. Temporal distribution of the incremental rainfall depths was determined using the NRCS Type I distribution curve. Using six-minute time increments, a maximum intensity of 0.17 inches per six-minute increment was calculated, which is approximately 0.03 inches-per-minute.

5.2.2 Drainage Areas

Proposed grading of the site is shown on Figure 5-1, Site Storm Water Plan, which includes arrows to show the direction of surface runoff flow. Basins were identified according to receiving water body and subbasins were delineated based upon drainage flow direction and coverage system design. A multi-layered cover system, which includes three-feet of cover soil, is proposed for most of the plant area, while a four-foot thick vegetated evapotranspiration cover is proposed for the slag pile. Both propose to use soil imported from fields south of the plant site.

As shown in Figure 5-1, approximately 47 percent of the covered site will be graded to allow surface runoff to flow to the northwest and into two existing sediment basins, DA15 and DA16, which are located on the west side of the facility. Sediment basin DA15 discharges to a 27-inch diameter concrete drain pipe and sediment basin DA16 discharges to an 18-inch diameter concrete pipe. Both pipes eventually join at a manhole and combine discharge to a 30-inch diameter pipe that flows to a storm water retention tank northwest of the plant site.

Approximately 36 percent of the site will be graded to drain into Lower Lake, including a diversion along the east side of the slag pile. With an area of over six acres, Lower Lake provides a significant amount of storm water capacity and detention time. The remainder of the site storm water will run off into either Prickly Pear Creek, as in the case of the north side



ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	SITE STORM WATER PLAN	FIGURE 5-1

UPDATE TIME: 9:28AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H007.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

of the slag pile, into Upper Lake, or into roadside ditches around the site perimeter. The north side of the slag pile accounts for another 23 percent of the runoff area, while the drainage area into Upper Lake accounts for approximately six percent. Drainage to roadside ditches will occur from a small strip of cover system along the perimeter of the cover and accounts for the remaining one percent of area. The total area of the cover is approximately 118 acres.

5.2.3 Runoff Losses

Losses associated with infiltration were based on the NRCS curve number (CN) method. CN is determined by soil type and the condition of vegetation. The highest possible CN is 98, representing a ground surface that is totally impermeable and all rainfall will become runoff. The NRCS Soil Survey reports that sandy loam from the field south of the plant, which is proposed as a borrow source for the cover system, is a Hydrologic Class B soil. The existing CAMU, which has a good grass cover, was used to judge the quality of vegetation that will be established once the site cover system is completed. A CN of 61, which corresponds to rangeland and grassland in class B soil and with good vegetation, was used for the proposed cover system that will include one to three feet of cover soil imported from fields south of the plant.

5.2.4 Time of Concentration

Time of concentration, Tc, which determines the shape of the runoff hydrograph from each subbasin, was determined by the Kirpich equation in the StormNET® model, which is

$$Tc = (0.01947(L^{0.77})(S^{-0.385}))$$

where: Tc = Time of Concentration (min)

L = Flow length (ft) and

S = Slope (ft/ft).

Each subbasin properties for average slope and flow length were entered into the model.

A summary of the site hydrologic characteristics for the basin discharging to outfall 001A is shown in Table 5-1.

TABLE 5-1. SITE HYDROLOGIC CHARACTERISTICS

Subbasin (Figure 5-1)	Drainage Area (acres)	Average Slope (%)	SCS Curve Number	Time of Concentration (min)
West Plant	23.2	3	61	7.1
Northeast Plant	20.2	3	61	7.6
West Slope Slag Pile	12.4	25	61	2.9
Total	55.8			

5.3 STORM WATER RUNOFF ANALYSIS RESULTS

Runoff from the capped areas of the site was modeled using StormNET®, a surface water hydrology and routing computer model. Using the design rainfall event (25-year, 24-hour storm), the model estimates surface runoff hydrographs from site subbasins and routes flows through conveyance channels or pipes to a receiving water or containment facility. From the storm water analysis results, that are found in Table 5-2, it appears that the existing storm water structures are adequate for the design runoff from the cover system and that runoff into the two monitored storm water discharge points, Outfall 001A and Lower Lake, account for 83 percent of the runoff.

TABLE 5-2. STORM WATER RUNOFF QUANTITIES AND RECEIVING WATERS

Basin	Area (Acres)	25-Yr Volume (Acre-Feet)	Percent Total (%)	Receiving Waters
West Plant	23.2	0.77	19.3	Outfall #001A
Northeast Plant	20.2	0.66	16.7	Outfall #001A
West Slope Slag Pile	12.4	0.44	11.2	Outfall #001A
Subtotal	55.8	1.87	47.2	Outfall #001A
East & South Slag Pile	20.3	0.72	18.1	Lower Lake
South Plant	22.2	0.71	17.9	Lower Lake
Subtotal	42.5	1.43	36.0	Lower Lake
North Slag Pile	12.1	0.42	10.6	Prickly Pear Creek
Southeast Plant	6.7	.22	5.5	Upper Lake
Site Perimeter	1.2	0.04	1.0	Roadway Ditches
Total	**118.3**	**3.97**	**100.0**	

Of primary concern, and the primary focus of the storm water runoff analysis, is the ability of the existing storm water facilities in the northwest corner of the site to adequately discharge and store runoff from the area. The estimated discharge from the site was routed through existing storm water pipes and eventually to the existing containment facility. Appropriate size and roughness information was entered into the model to reasonably estimate the peak flows and discharge volumes for each component of the system. As summarized in Table 5-3, the analysis concluded that the existing facilities are adequate to handle the runoff from at least a 25-year storm event on the site.

TABLE 5-3. SUMMARY OF RUNOFF RESULTS AT EXISTING FACILITY COMPONENTS

Existing Storm Water Component	Pipe Capacity (cfs)	Peak Discharge (cfs)	Peak Discharge to Pipe Capacity Ratio
Sediment Basin DA15 (27-inch)	17.9	0.82	0.05
Sediment Basin DA16 (18-inch)	3.45	1.23	0.36
Junction of DA15 and DA16	60.9	2.0	0.03
	Storage Capacity (acre-feet)	Runoff Volume (acre-feet)	Runoff Volume to Storage Ratio
Storm Water Containment Facility	3.9*	3.0	0.77

*Includes Steel Tank + Concrete Secondary Containment. Does not include the surrounding depression, which adds an additional 5.2 acre-feet of storage (See Figure 5-1).

5.4 SURFACE RUNOFF MONITORING

Surface runoff water quality will be monitored for a period of time using existing storm water monitoring practices to determine effectiveness of the site cover. Therefore, until the site is fully covered, storm water entering the retention basin will be handled in the same manner as it is currently. Runoff will be temporarily held in the containment facility prior to being pumped back to the water treatment plant, treated and discharged to Lower Lake. The water treatment plant is expected to be one of the last structures to be demolished and will remain operable until the site cover system is substantially complete. Never the less, storm water from the retention basin will be tested before discharge to public waters for a period of time following closure of the water treatment plant in order to ensure that the cover system has adequately addressed water quality concerns. Similarly, discharge from Lower Lake will continue to be monitored as it is currently until the data suggests that water quality concerns have been adequately addressed.

6.0 STREAMBANK PROTECTION

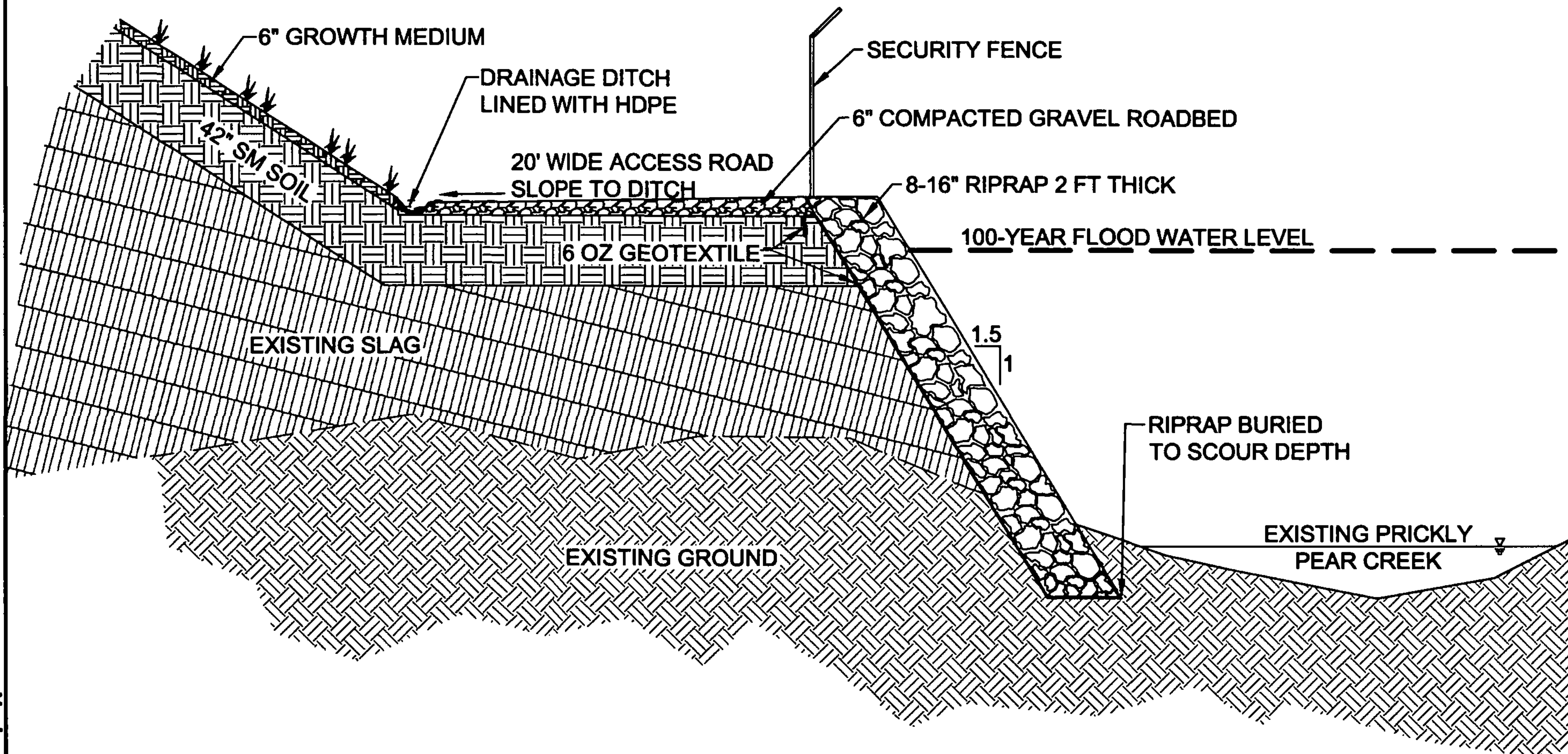
The final cover system on the slag pile is adjacent to Prickly Pear Creek and in several locations it will intersect the stream bank. Riprap armor is proposed along the east side of the slag pile as part of the final cover system in order to prevent erosion of slag from up to the 100-year flow event in Prickly Pear Creek. Discharge and water surface elevations for the 100-year flow in Prickly Pear Creek were taken from the HEC-2 flood model for the City of East Helena Flood Insurance Study (FEMA, 1985).

Riprap armor was appropriately sized for flow velocities from the 100-year Prickly Pear Creek flow of 2,190 cubic feet per second (cfs). Information from the Federal Emergency Management Agency (FEMA) Flood Insurance Studies for Lewis and Clark County and the City of East Helena were input into the HEC-RAS, River Analysis System (USACOE, 2005), hydraulic model to determine flow velocities and bank full elevations from the 100-year flow event. Channel flow velocities in Prickly Pear Creek in this area during the 100-year flow event range from 5.24 feet per second (fps) to 7.48 fps. Therefore, the riprap design for this cover system used a flow velocity of 8 fps.

Riprap armor was sized in accordance with the California Bank and Shore Protection Design Manual (CALTRANS, 2000) and the U.S. Army Corps of Engineers Hydraulic Design of Flood Control Channels Design Guide (USACOE, 1995). Calculations for riprap design, which are included in Appendix E, resulted in specification of a two-foot thick layer of 16-inch (maximum) riprap with a specific gravity of 2.65 or greater. Specifications for the riprap are included in Appendix A. As shown in Figure 6-1, the design includes a maximum slope of 1.5:1 for the armored bank of Prickly Pear Creek and a layer of geotextile filter fabric under the riprap.

Table 6-1 is a summary of the proposed riprap armoring design.

UPDATE TIME: 9:13AM
SDP\HEL\020708\I:\Land Projects\705402\dwg\705402H013.dwg



Hydrometrics, Inc.
Consulting Scientists and Engineers

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	TYPICAL ROADWAY AND RIPRAP DETAIL	FIGURE 6-1

TABLE 6-1. DESIGN SUMMARY OF PROPOSED RIPRAP ARMORING ALONG PRICKLY PEAR CREEK

Prickly Pear Creek Station (from City of East Helena FIS)	100-Year Water Surface Elevation (NGVD)	Elevation of Top of Riprap (NGVD)	Elevation of Bottom of Riprap (NGVD)
N	3903.79	3905.79	3898.7
M	3896.36	3898.36	3889.5
L	3890.31	3892.31	3883.2

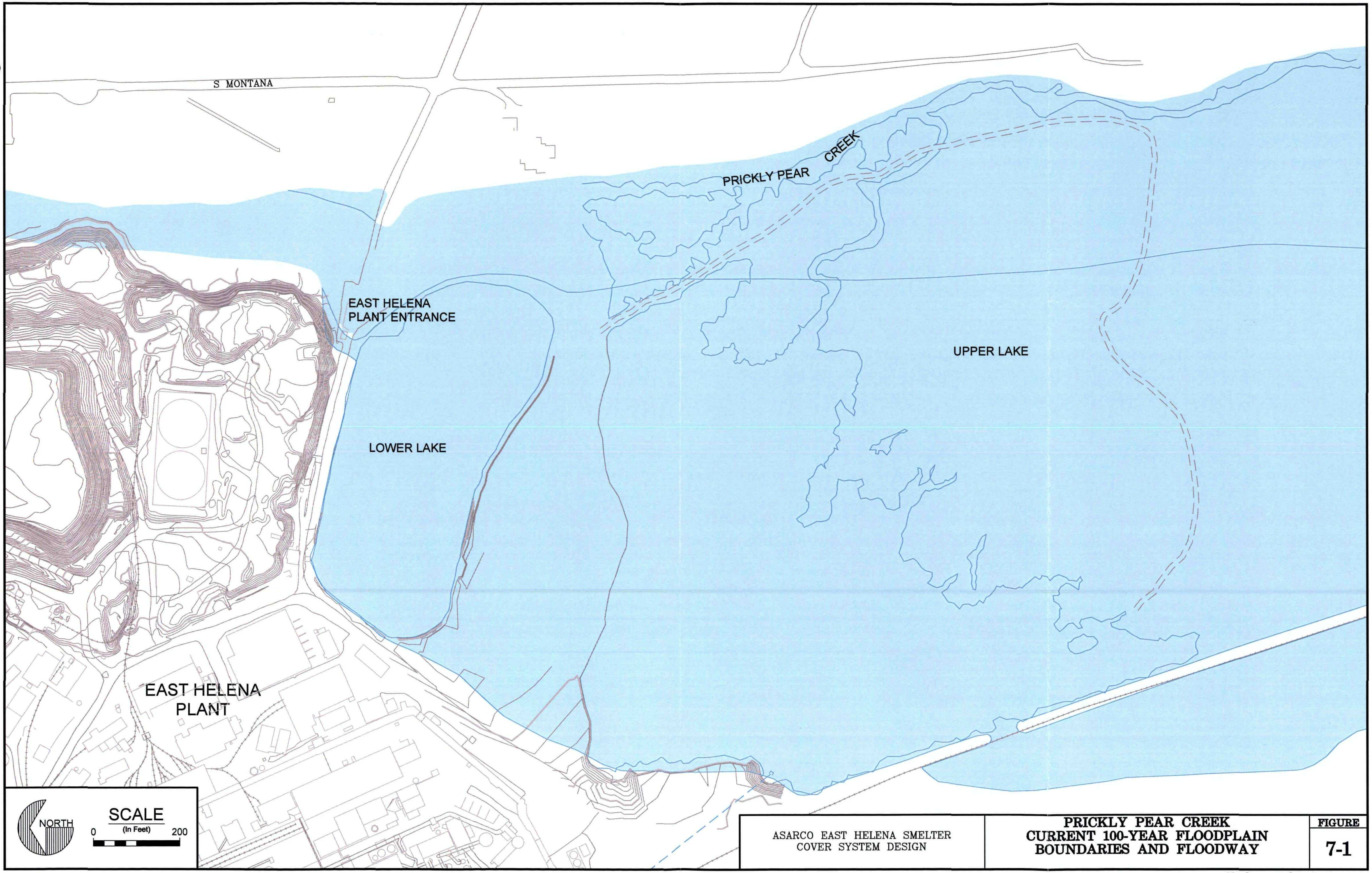
7.0 FLOODPLAIN PROTECTION

Hydrometrics conducted a flood analysis of Prickly Pear Creek for the purpose of analyzing impacts to the site cover system and evaluating options for mitigating flood impacts. Prickly Pear Creek flows generally in a northerly direction along the east side of the smelter property. Existing floodplain boundaries for the 100-year flood for Prickly Pear Creek, which is defined as a flood having a one percent probability of exceedance in any given year, are published in the Flood Insurance Rate Maps (FIRMs) for the Flood Insurance Studies (FISs) for the City of East Helena (FEMA, 1985) and Lewis & Clark County (FEMA, 2002). The current floodplain boundaries in the area of Asarco's East Helena Plant, shown as blue shading on Figure 7-1, encompass all of Upper and Lower Lake.

The objectives of this analysis, which is contained in Appendix F, included:

1. Characterize the current impacts to the East Helena Plant from a 100-year flood on Prickly Pear Creek, using updated topographic data in the area of Lower Lake.
2. Evaluate the feasibility of constructing a dike or placing fill to prevent Prickly Pear Creek from flooding the East Helena Plant area, and evaluate impacts to the Prickly Pear Creek floodplain from construction of the dike or fill.
3. Evaluate impacts to Prickly Pear Creek floodplain and the East Helena Plant resulting from removal of all or a portion of the dam that is generally referred to as the Smelter Dam, located at the east entrance to the plant.

Analysis of the impact of a 100-year flood concluded that there are a number of options for preventing Prickly Pear Creek from flooding the East Helena Plant site. However, there are regulatory limitations to building a protective dike because it would be within the designated floodway and privately owned. Removing the entire east-entrance dam structure also presents problems with implementation because of significant stream regrading and reconstruction.



ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

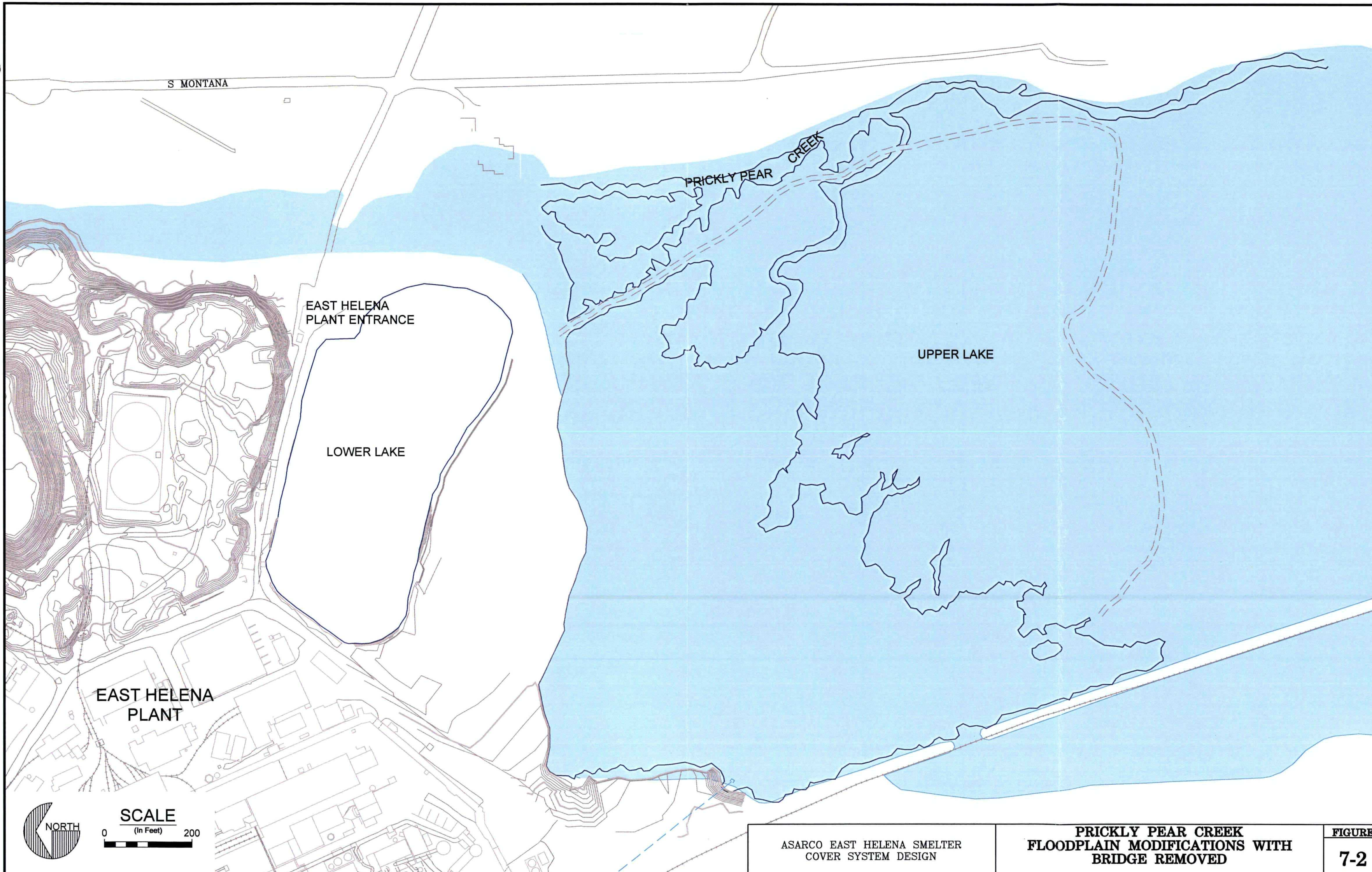
PRICKLY PEAR CREEK
CURRENT 100-YEAR FLOODPLAIN
BOUNDARIES AND FLOODWAY

FIGURE
7-1

UPDATE TIME: 10:35AM
LT \HEL\020708\I:\Land Projects\705401\dwg\705401H0029.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

At this time, removal of the east entrance bridge structure and abutment ramps appears to be the best alternative. This alternative would not require removal of the bottom portion of the dam, which would remain in place. Therefore, it will maintain the stream grade at its current elevation. However, as shown in Figure 7-2, removal of the bridge will lower the 100-year flood water surface elevations upstream of the dam and adjacent to Lower Lake sufficiently to protect the site and cover system. Removal of the bridge will not affect downstream 100-year flood elevations (See Appendix F). At a location approximately 600 feet upstream of the dam near the northern end of Upper Lake, removal of the bridge will lower the 100-year flood water surface elevation by only about 0.3 feet. However, at the location of the bridge, its removal will lower the 100-year water surface elevation approximately 2.9 feet. The most significant disadvantage to bridge removal is that it will eliminate the east entrance to the plant, but this may actually benefit site security of the plant. Figures 7-3 and 7-4 show the portions of the bridge structure that will be removed.



ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

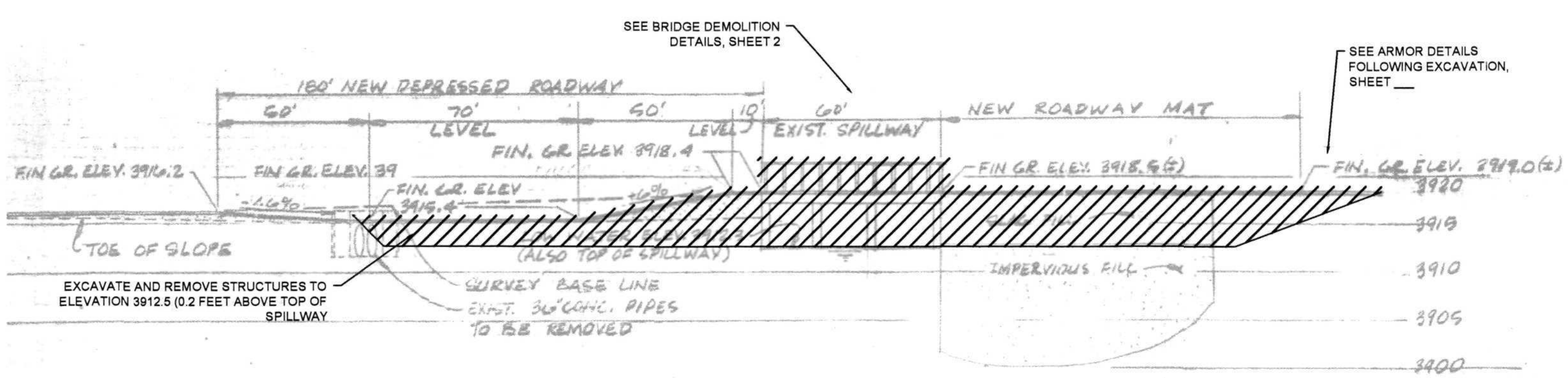
PRICKLY PEAR CREEK FLOODPLAIN MODIFICATIONS WITH BRIDGE REMOVED

FIGURE 7-2

UPDATE TIME: 9:32AM
LT \HEL\020708\I:\Land Projects\705401\dwg\705401H0030.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

PLAN VIEW
SCALE: 1"=40'



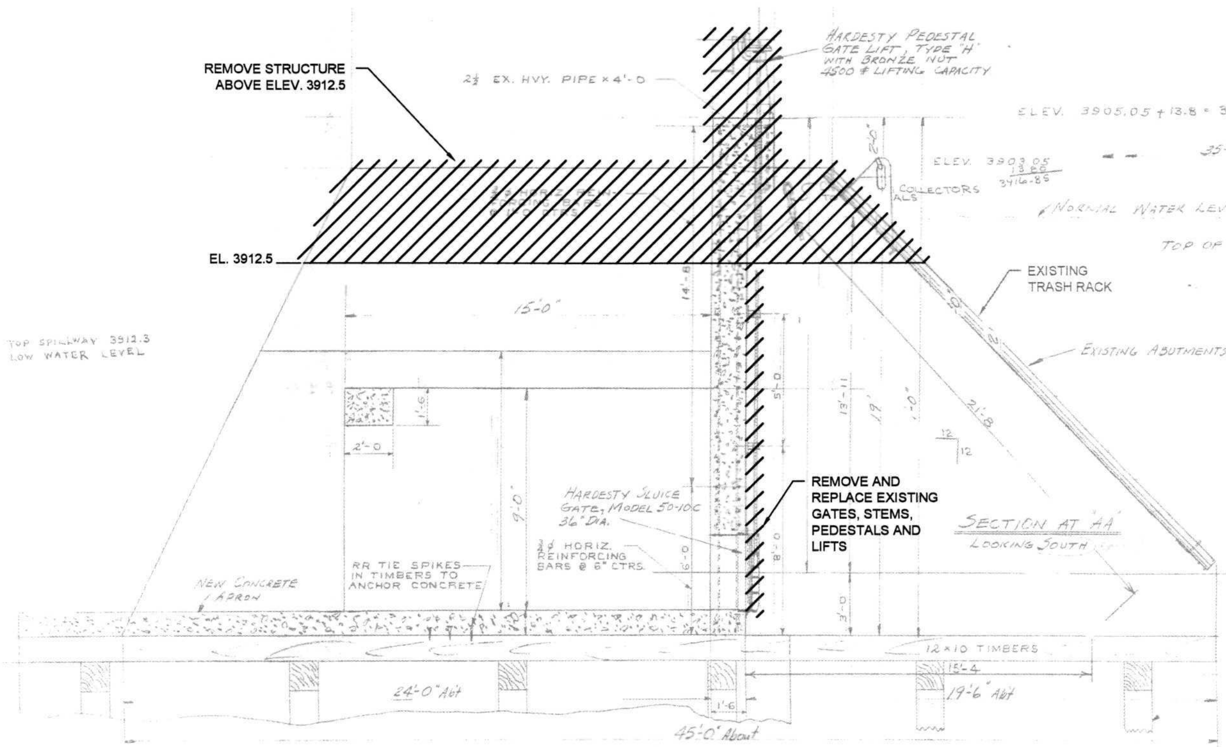
SECTION A PROFILE VIEW

NOTE:
EXISTING CONDITIONS DEPICTED ARE AS SHOWN OF DRAWING ASARCO 1-7087 (1981). ACTUAL EXISTING CONDITIONS MAY HAVE CHANGED.

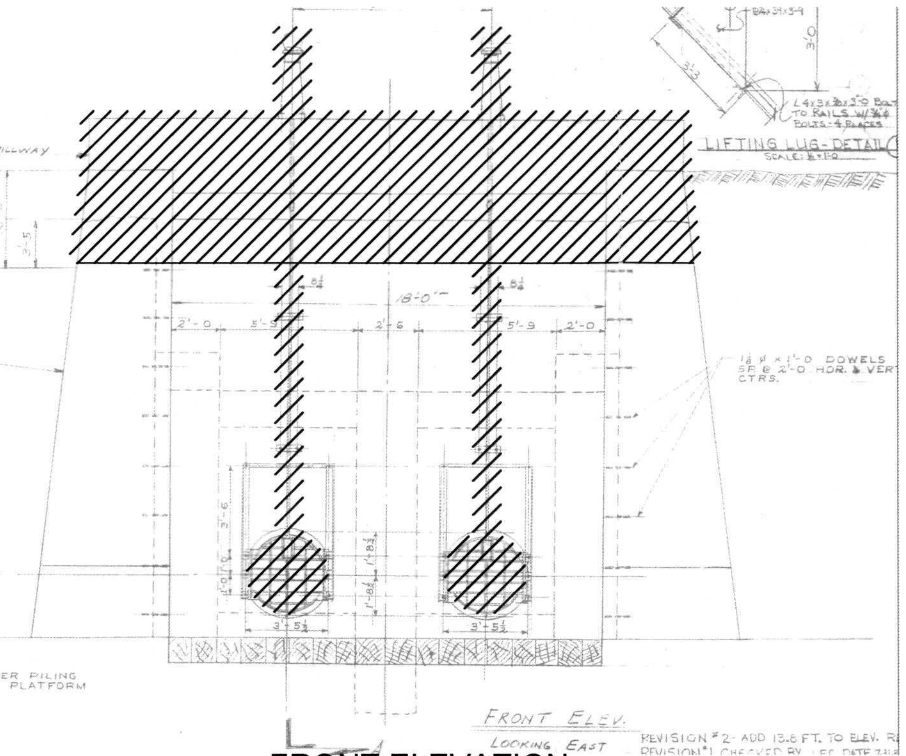
ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	PLAN VIEW OF BRIDGE STRUCTURE TO BE REMOVED	FIGURE 7-3

UPDATE TIME: 12:11AM
SDP\HEL\020708\I:\Land Projects\705403\dwg\705403H001.dwg

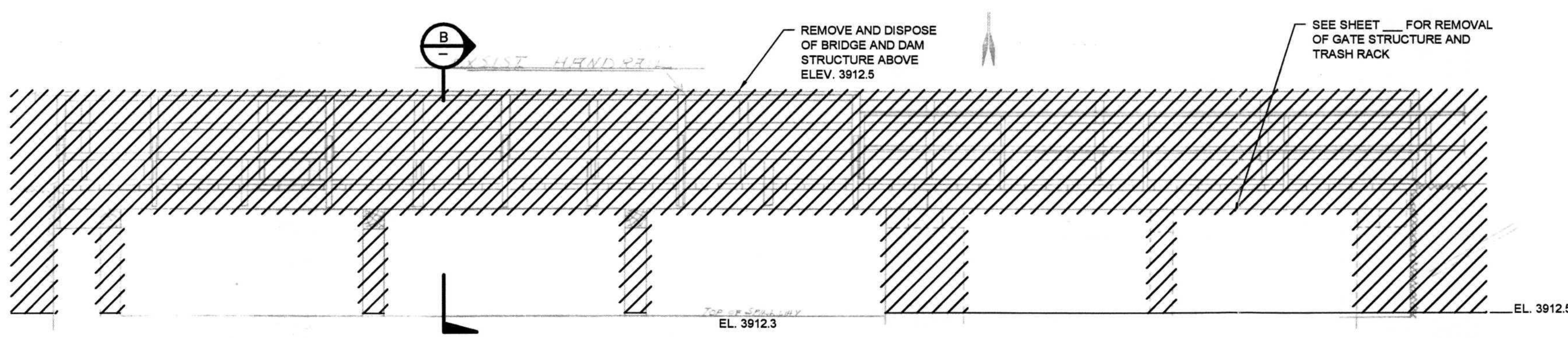
Hydrometrics, Inc.
Consulting Scientists and Engineers



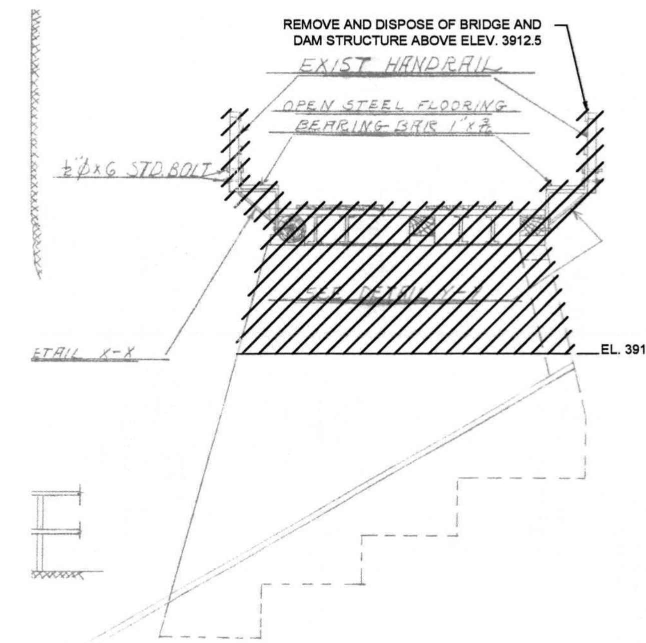
SIDE ELEVATION
SCALE: 1"=8'
LOOKING EAST



FRONT ELEVATION
SCALE: 1"=8'
LOOKING NORTH



BRIDGE PROFILE
SCALE: 1"=8'



SECTION B BRIDGE
SCALE: 1"=8'

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	SECTION VIEW OF BRIDGE STRUCTURE TO BE REMOVED	FIGURE 7-4

UPDATE TIME: 12:13AM
SDP\HEL\020708\I:\Land Projects\705403\dwg\705403H002.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

8.0 SECURITY AND MAINTENANCE

Longevity of the cover system is an integral part of the protection of both human health and the environment. Therefore, it is critical that the cover system be protected from both human and animal interaction. Since a phased approach will be taken to installing the final cover system, temporary security and maintenance procedures will be implemented. Temporary and long-term site security and maintenance will ensure that the integrity of the cover system is not jeopardized.

8.1 TEMPORARY SITE SECURITY AND MAINTENANCE

The Asarco East Helena Smelter facility will be fenced with a 6-foot high woven wire farm fence installed in accordance with Montana Department of Transportation specification 712.02 until completion of the cover system or until it is replaced with permanent fencing. A single strand of barbed wire will be strung 3-inches above the top of the woven wire for added security. Gates (24 feet wide) will be provided at the access roads. Temporary orange poly fence (safety fence) will be installed along the interior edges of the final cover system to eliminate the potential for disturbance to the cover system between construction seasons.

Cover system liner will be exposed between construction seasons along the interior perimeter of the final cover system, as explained in Section 9, and will require routine inspection and maintenance. Temporary on-site maintenance items are to include repairs to the exposed liner, seams, and sandbags. Exposed cover liner integrity and anchorage are the primary focus of scheduled inspection and preventative maintenance. Periodic inspection of other features, such as above-ground portions of monitoring wells and storm water controls, will also be required.

8.1.1 Housekeeping

Liner Anchorage – Sandbags that are used to anchor the membrane liner may need periodic adjustment to ensure they maintain proper spacing.

8.1.2 Routine Inspection and Maintenance

Problems may be encountered during the construction of the cover system or prior to permanent closure of the site. Several problems that may be encountered during routine inspection include subsidence, rips and tears of liners, liner seam separation, and liner anchorage.

1. Subsidence - When an area experiences excessive localized settlement, the cover may no longer drain properly. Even so, there may not be a problem unless the area is large, there is continued ponding, or the cover system liner has been damaged.

If it is determined that a repair must be made, the necessary steps involved are:

a. Determine limits of area to be repaired.
b. Remove cover soil from area.
c. Cut and remove cover system liners.
d. Fill depression and grade for proper drainage.
e. Install and seam new cover system liners.
f. Test seams to ensure integrity of repair.
g. Replace cover soil and revegetate.

2. Rips and tears - Repair of rips and tears in the liner is necessary not only to prevent water from leaking through but also to prevent wind from getting under the liner. If allowed to get under the liner, high winds may inflate the surface of the cover system. Inspection for rips and tears should be conducted prior to cover soil placement and along edges of the cover system with exposed liner. If it is determined that a repair must be made, the cover system liner should repaired by appropriate methods.

3. Seam separation – Repair of separating or inadequately sealed seams is necessary for the same reasons as repair of rips and tears in the liner. Seams can be temporarily repaired using seaming tape, but should be permanently repaired by appropriate methods as soon as a liner installer can be called to the site.

4. Liner anchorage – High winds may cause liner edges to pull out or temporary sandbags or sand tubes to displace along edges of the cover system with exposed liner. If this occurs, anchor trenches will be excavated, liner edges reinstalled, and the trench filled and compacted in accordance with the liner installation plans. Sandbags or sand tubes will be repositioned to provide evenly spaced anchorage on the cover system liner.

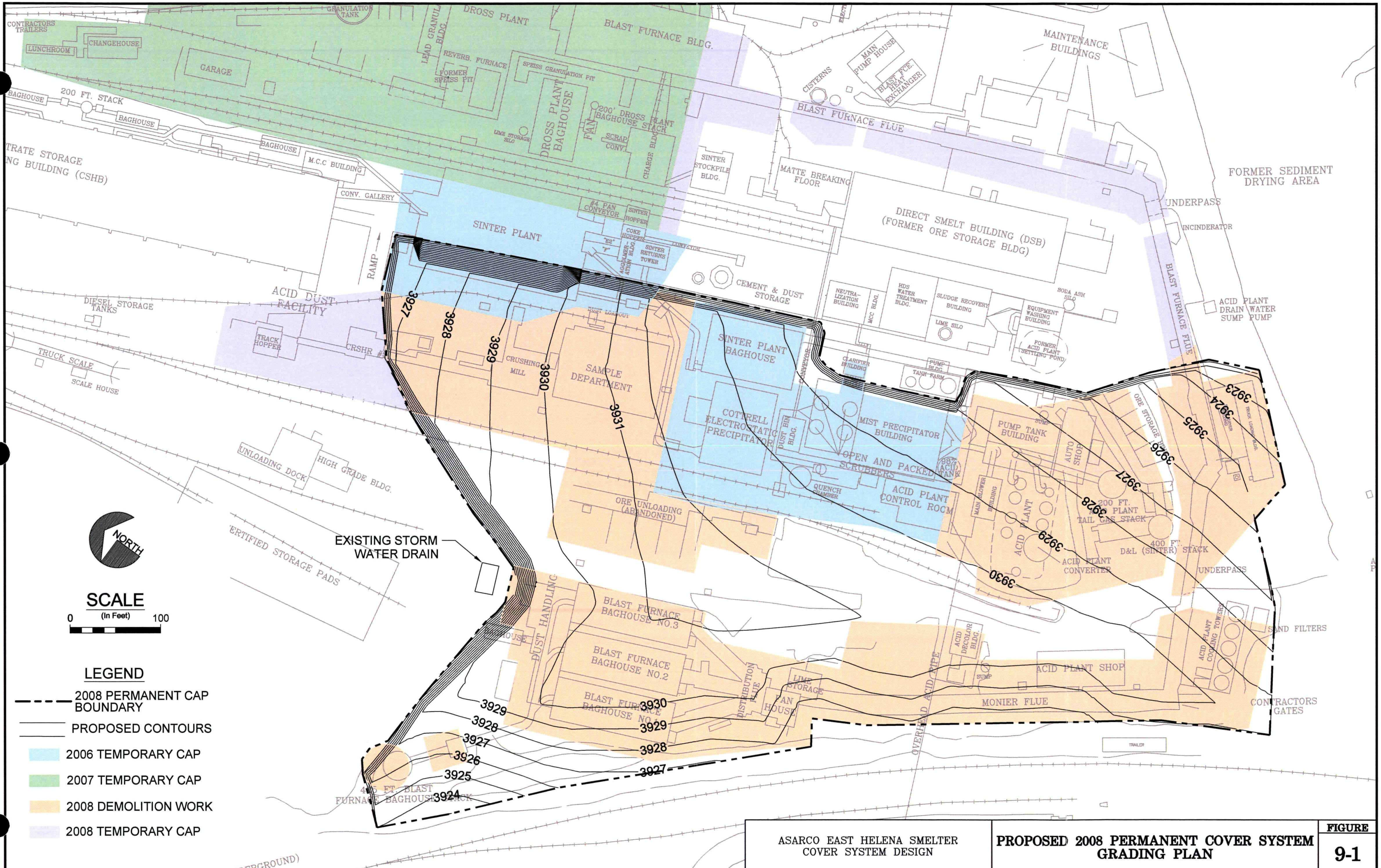
8.2 LONG-TERM SITE SECURITY AND MAINTENANCE

Permanent site security fencing will be installed as sections of the cover system are completed along the site boundary. An 8-foot high chain link fence with a 3-strand barbed wire top section will be used for permanent site security fencing. Gates (20-24 feet wide) will be provided at the access roads.

Long-term maintenance will be conducted, as part of a post-closure monitoring plan, which will be not be presented at this time. The post-closure monitoring plan, to be submitted after completion of the cover system, will include information on the long-term monitoring of the cover system integrity including subsidence and surface erosion.

9.0 2008 COVER SYSTEM CONSTRUCTION

Asarco will prepare the 2008 Cleaning and Demolition Project Work Plan for submittal no later than March 15, 2008. Once approval is received from the Montana Department of Environmental Quality (MDEQ), Asarco plans to proceed with the cleaning and demolition work set forth in the Work Plan. The 2008 schedule for cleaning and demolition will coincide with the availability of the CAMU Phase 2 to accept wastes generated under this Work Plan. Asarco proposes to proceed with construction of the proposed cover system to the extent practical once cleaning and demolition is completed, eliminating the need for placement of a less protective temporary cap in some areas. Figure 9-1 shows the area of the site for which Asarco proposes to complete cleaning, demolition, grading, and cover system construction during calendar year 2008. The proposed construction includes permanently anchoring the cover system along the perimeter of the site. However, interior edges of the cover system would remain temporarily anchored to the existing pavement or surface with batten boards and sandbags. Figure 9-2 shows a typical detail for how the grading and cover system would temporarily be terminated along interior edges. Asarco anticipates that the permanent cover system will require less maintenance and repair and be more protective of the site than if temporary caps are used.



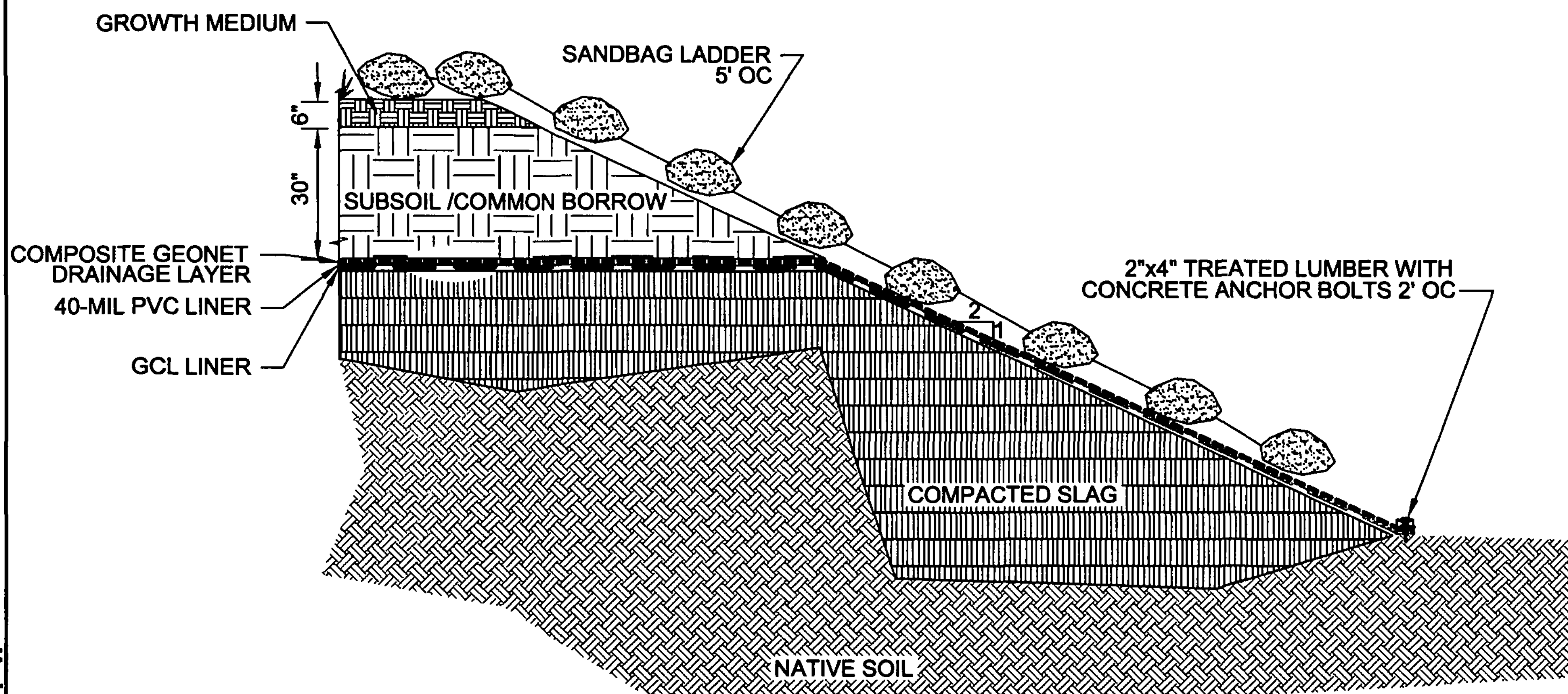
ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

PROPOSED 2008 PERMANENT COVER SYSTEM GRADING PLAN

FIGURE 9-1

UPDATE TIME: 10:08AM
MWR\ HEL\ 020708 \ I:\Land Projects\705402\dwg\705402H019.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers



ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

TEMPORARY COVER SYSTEM TERMINATION

FIGURE **9-2**

Hydrometrics, Inc.
Consulting Scientists and Engineers

UPDATE TIME: 11:04AM
SDP\HEL\020708\I:\Land Projects\705402\dwg\705402H014.dwg

10.0 IMPLEMENTATION OF THE EAST HELENA SUPPLEMENTAL ENVIRONMENTAL PROJECT

Design and construction activities that are necessary to implement the SEP will be conducted in three phases. Phase 1 addresses work associated with implementation of a flow short circuit system between Upper Lake and Lower Lake to minimize the flow through the fill between these water bodies. Phase 2 of the work addresses those work items associated with the wetlands and riparian areas that make up the shoreline of Lower and Upper Lakes. Phase 3 includes those work items associated with the four-acre upland area positioned between the two lakes.

As part of general construction planning, submission and approval of a Five Year Noxious Weed Management Program is necessary to comply with State of Montana County Noxious Weed Control Act (Title 7, Chapter 22, Sections 7-22-2101 through 7-22-2153) MCA and Rules 4.5.201 through 4.5.204 for activities proposed in this SEP. A SEP Weed Management Plan will be developed for Lewis and Clark County Weed District approval prior to the implementation of Phase 1.

10.1 PHASE 1

Three gated pipe conveyances between Upper and Lower Lake will be constructed to channel controlled flows of water from Upper Lake to Lower Lake (Figure 10-1). These constructed flow corridors will short circuit flow through the fill between the lakes. The result will be a preferred pathway between the ponds, a leveling of water levels between Upper and Lower Lake, and a minimization of groundwater flux through the fill between the ponds. The combination of reduced groundwater flux between the ponds and direct flow connection between Upper and Lower Lakes will result in improved water quality in Lower Lake that should ultimately meet 1989 Process Pond ROD (EPA, 1989) standards for Lower Lake (Table 10-1). Improvements in water quality and level controls will also augment efforts for further vegetation and wildlife habitat enhancements.

ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

RIPARIAN AREA ENHANCEMENTS

FIGURE
10-1

UPDATE TIME: 11:35AM
LT \HEL\020708\I:\Land Projects\705402\dwg\ 705402H020.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

TABLE 10-1. ROD STANDARDS FOR LOWER LAKE

Constituents	ROD Standard (mg/L)*
Arsenic	0.02
Cadmium	0.01
Copper	0.004-0.008
Lead	0.05
Zinc	0.11

**Environmental Protection Agency, 1989.*

Table 10-2 shows existing soil metal data, soil leachate data (SPLP) and water quality data from soil sample sites and monitoring wells completed in the areas between Lower Lake and Prickly Pear Creek. Although total metals in the fill are elevated in arsenic and metals, concentrations in groundwater are mildly elevated and relatively low. Comparison with SPLP concentrations and groundwater well water quality results show leachate and groundwater concentrations are similar, suggesting the contribution of arsenic and metals to groundwater in the fill is limited.

Table 10-3 shows results of adsorption testing conducted as part of the Phase I RFI contaminant modeling effort. This effort is described in detail in the Phase I RFI report (ACI, 2003). Part of this effort was to predict the impacts of unsaturated soils on groundwater. As Table 10-3 shows, the fill between Upper Lake and Lower Lake has a high capacity to adsorb arsenic, particularly, at higher concentrations. However the potential for soil leaching (negative soil adsorption values) is low. Only one test sample (OUS-SS18, SOL 8) showed a slightly negative value, indicating a slight leaching potential in water with low arsenic concentrations.

Infiltration model results are shown on Figure 10-2. As the figure shows, limited impacts were predicted for the fill between Upper and Lower Lake and predicted groundwater concentration from fill soils is less than 0.01 mg/l for arsenic. The predicted elevated concentrations at the west edge of the fill (0.1 ppm contour, orange area) are a result of

Table 10-2. Soil Leachate and Water Quality Data - Fill Area Between Upper and Lower Lake

Site/ Sample #	Sample Interval (ft)	Sample Date	Sample Time (hr/min/sec)	Analytical Parameters	As (ppm)	Cd (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)
UOS-SS11	12-24"	10/3/01	11:10	Total Metals SPLP	9256 2.000	451 0.410	4666 0.015	26492 0.140	7043 1.900
UOS-SS12	12-36"	10/3/01	9:40	Total Metals SPLP	214 0.012	71 0.007	542 <.004	2804 <.005	2478 0.032
UOS-SS18	0-4"	10/3/01	13:50	Total Metals SPLP	972 0.06	582 0.10	1939 0.0070	9676 0.0170	6578 0.0850
	24-36"	10/3/01	14:05	Total Metals SPLP	1815 0.044	728 0.670	4375 0.023	22680 0.260	14742 1.300
APSD-7		11/14/01		Dis Metals GW	6.7	0.2	0.009	0.02	0.5
APSD-8		11/14/01		Dis Metals GW	0.7	< 0.001	< 0.004	< 0.005	< 0.02
APSD-9		11/14/01		Dis Metals GW	0.9	0.005	0.007	0.008	0.2
APSD-10		11/14/01		Dis Metals GW	0.5	< 0.001	< 0.004	< 0.005	0.03
APSD-11		11/14/01		Dis Metals GW	0.2	< 0.001	< 0.004	< 0.005	0.03
APSD-12		11/14/01		Dis Metals GW	0.07	< 0.001	< 0.004	< 0.005	< 0.02

Color indicates surface soil site and monitoring well proximity.

Source: Appendix 7, Phase I RFI Report, ACI 2003.

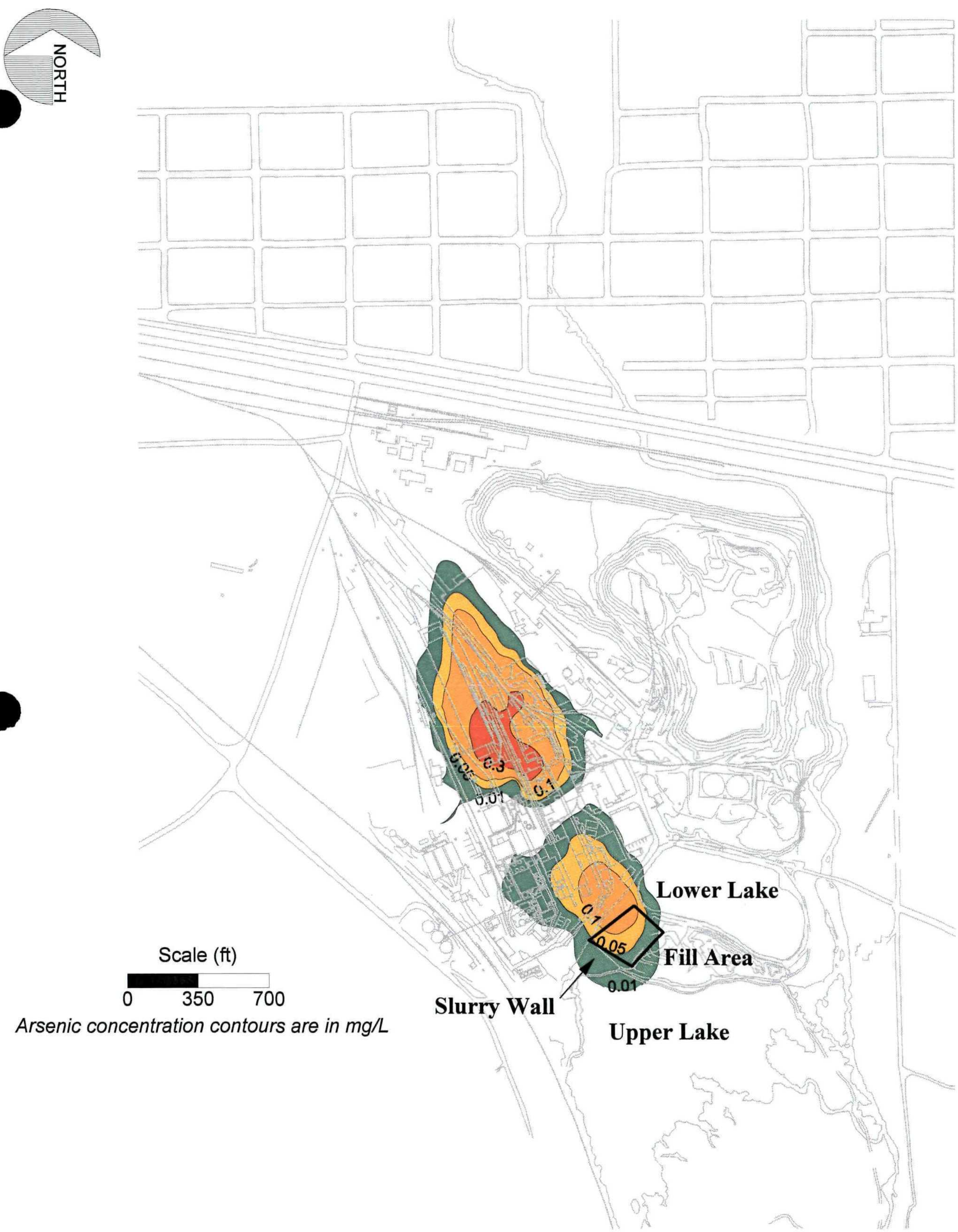
Table 10-3. Soil Adsorption Testing Data - Fill Area Between Upper and Lower Lake

Site/ Sample #	Sample Interval (ft)	Analytical Parameters	SOL 1 As (ppm)	SOL 2 As (ppm)	SOL 3 As (ppm)	SOL 4 As (ppm)	SOL 5 As (ppm)	SOL 6 As (ppm)	SOL 7 As (ppm)	SOL 8 As (ppm)
UOS-SS11	2-3'	Initial Concentration (mg/l)	186.5	95.5	48	24	9.65	4	1	0.12
		Final Concentration (mg/l)	83	30	6.4	0.98	0.21	0.086	0.057	0.048
		Adsorbed Concentration (ug/g)	1035	655	416.0	230.2	94.4	39.14	9.43	0.72
UOS-SS12	2-3'	Initial Concentration (mg/l)	186.5	95.5	48	24	9.65	4	1	0.12
		Final Concentration (mg/l)	112	52	22	8.2	1.8	0.59	0.2	0.11
		Adsorbed Concentration (ug/g)	745	435	260	158	78.5	34.1	8	0.1
UOS-SS18	2-3'	Initial Concentration (mg/l)	186.5	95.5	48	24	9.65	4	1	0.12
		Final Concentration (mg/l)	77	27	5.8	1.9	0.36	0.27	0.13	0.15
		Adsorbed Concentration (ug/g)	1095	685	422	221	92.9	37.3	8.7	-0.3

Note: Negative adsorption concentrations represent metal(s) leaching from soils.

Color indicates surface soil site and monitoring well proximity.

Source: Appendix 7, Phase I RFI Report, ACI 2003.



20 yr simulation

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	SIMULATED ARSENIC CONTRIBUTION FROM SHALLOW PLANT SITE SOILS	FIGURE 10-2

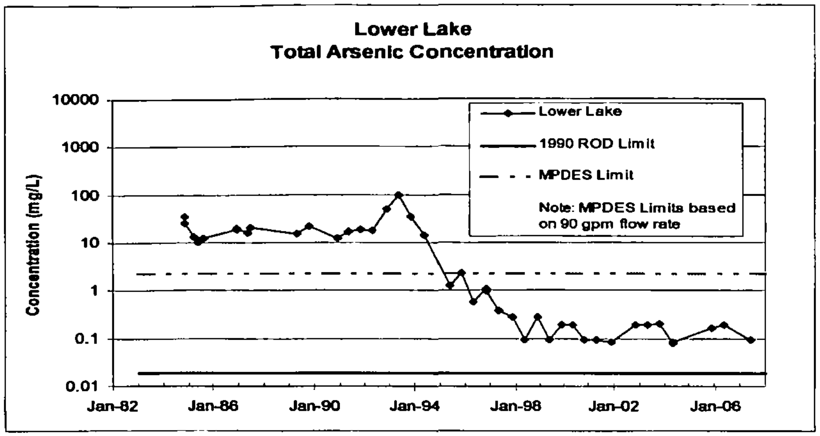
K:/PROJECT/7054/7054-ASshollowsoil.SRF

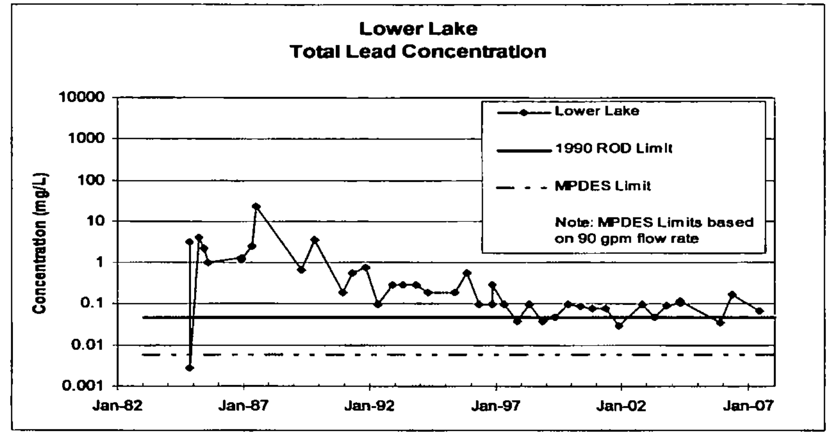
elevated concentrations in the former acid plant sediment drying area. This area has since been isolated by construction of a slurry wall in 2006 (Figure 10-2).

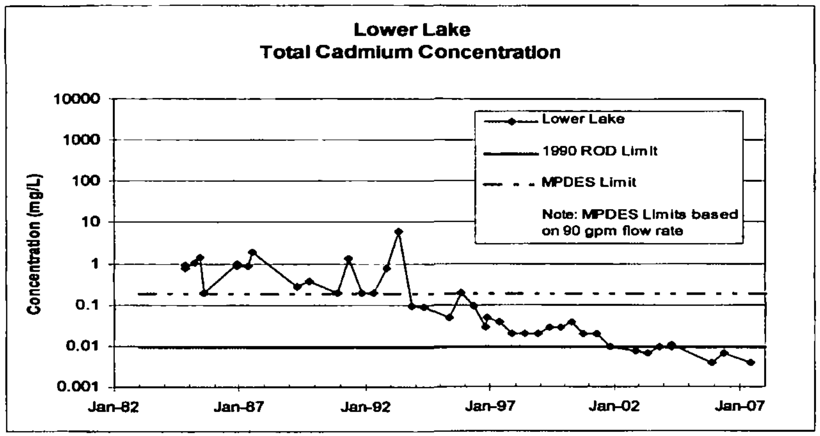
Figure 10-3 shows water quality in Lower Lake. MPDES limits shown on Figure 10-3 represents the discharge limits from HDS water treatment plant which discharges into Lower Lake. As the figure shows, Lower Lake has shown a generally steady trend of water quality improvements in recent years for most of the monitored parameters. Cadmium and zinc generally are below CERCLA ROD limits in recent years, and lead is generally near or below limits. Copper show a steady but slow improving trend over the last 15 years and projection of this trend suggests improvement that would meet ROD limits in about 15 additional years. Arsenic shows a relatively flat pattern in recent years and concentrations remain near the 0.1 mg/l level. This is similar to the concentrations observed in the fill between Upper Lake and Lower Lake and suggests groundwater flow through the fill may be influencing arsenic concentration trends in Lower Lake. However, establishment of the three flow conveyances to channel flow through the fill between Upper Lake and Lower Lake, along with the cover system as described in Section 10.3, may significantly improve these generally positive water quality improvement trends, and should allow Lower Lake water quality to meet CERCLA ROD limits.

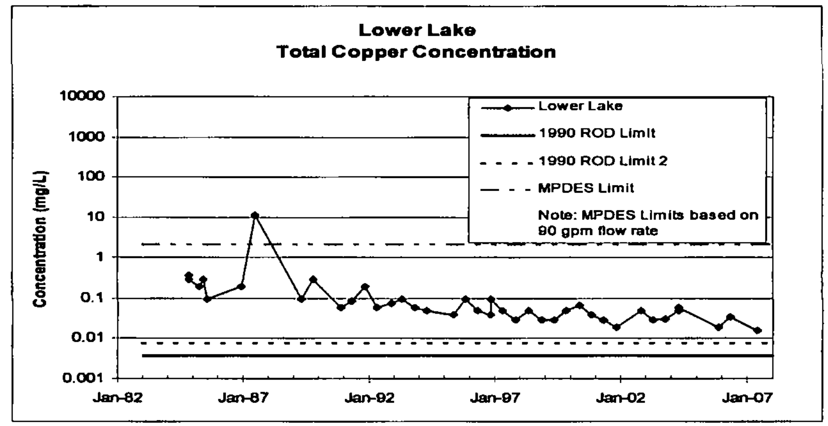
10.1.1 Flow Conveyance Design and Installation

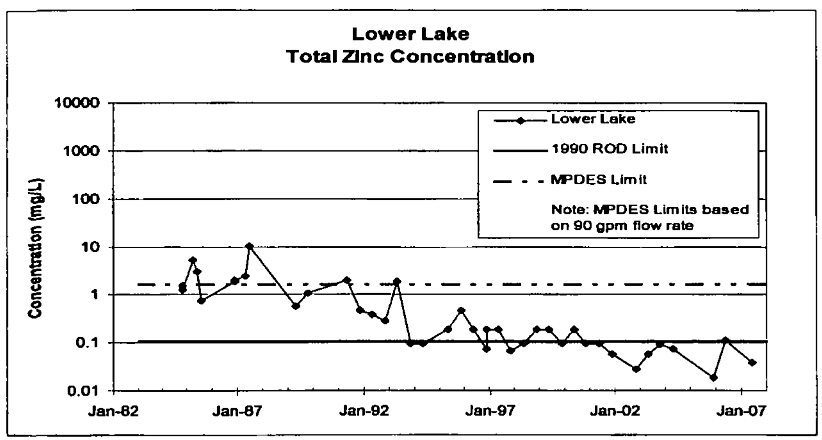
Figure 10-4 shows general conveyance details. The conveyances will be constructed of 8-inch diameter HDPE pipe. Water levels and flows between Upper and Lower Lake will be controlled by a drop pipe inlet installed on the Upper Lake side of the culverts and by back-flow control gates (Flap-gates) located on the Lower Lake side (Figure 10-4). Drop-inlets on the pipes will allow water to flow out of Upper Lake and into Lower Lake when water level rise in Upper Lake.



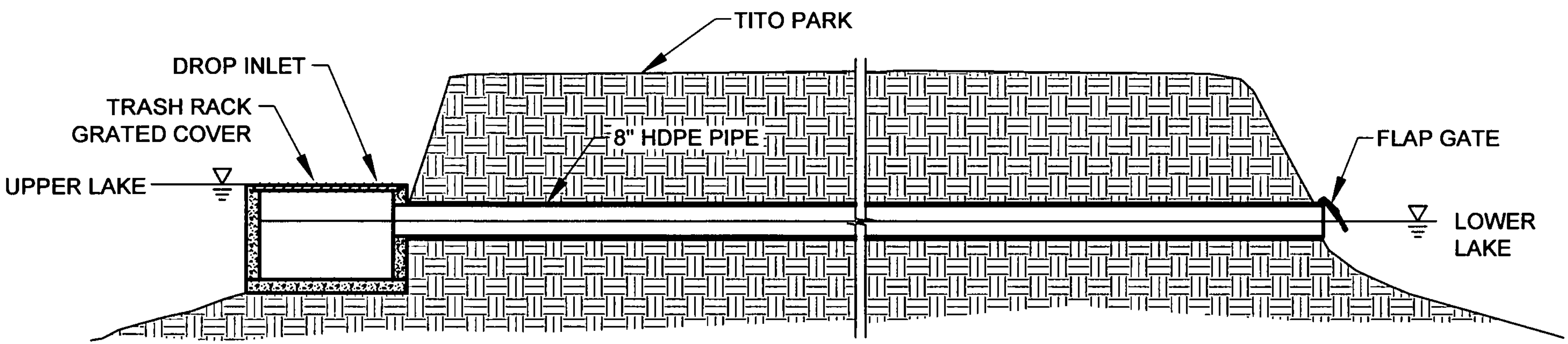








	ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	WATER QUALITY TRENDS IN LOWER LAKE	FIGURE 10-3



UPDATE TIME: 9:10AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H024.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	**GENERAL CONVEYANCE DETAIL**	FIGURE **10-4**

10.1.2 Installation Schedule

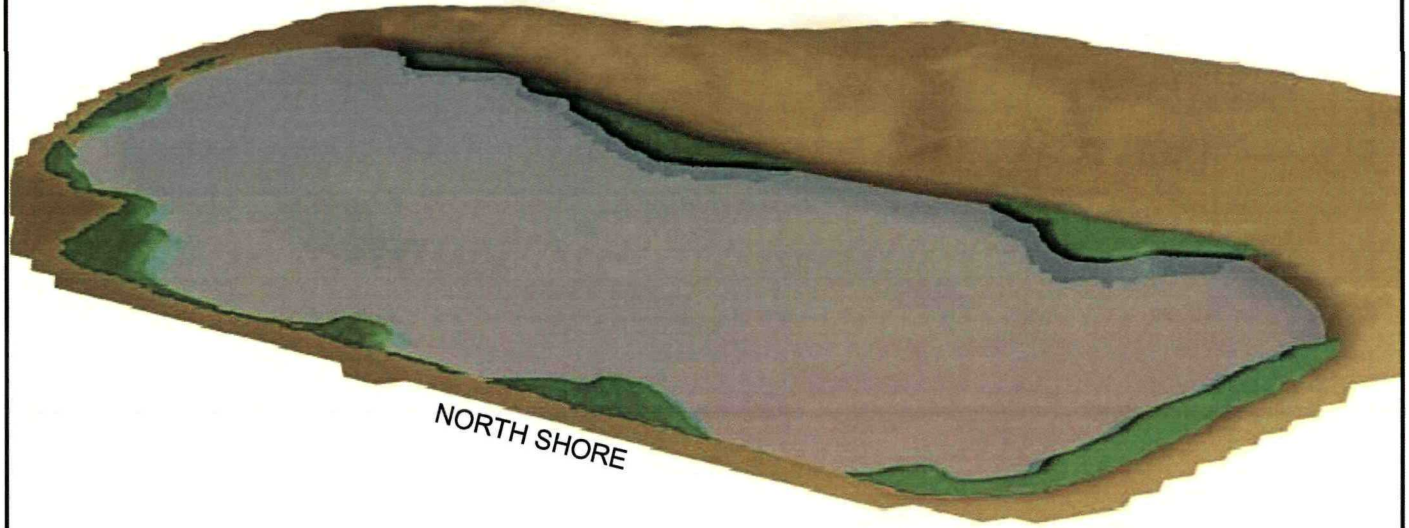
The conveyances will be installed in calendar year 2008, before implementation of the shoreline improvements (see Section 10.2) and the cover system in the fill area between Upper and Lower Lake (see Section 10.3). This approach allows supplemental monitoring of Lower Lake and groundwater in the fill area and allows assessment of the effectiveness of this approach before the engineered cover is installed in the area.

10.2 PHASE 2

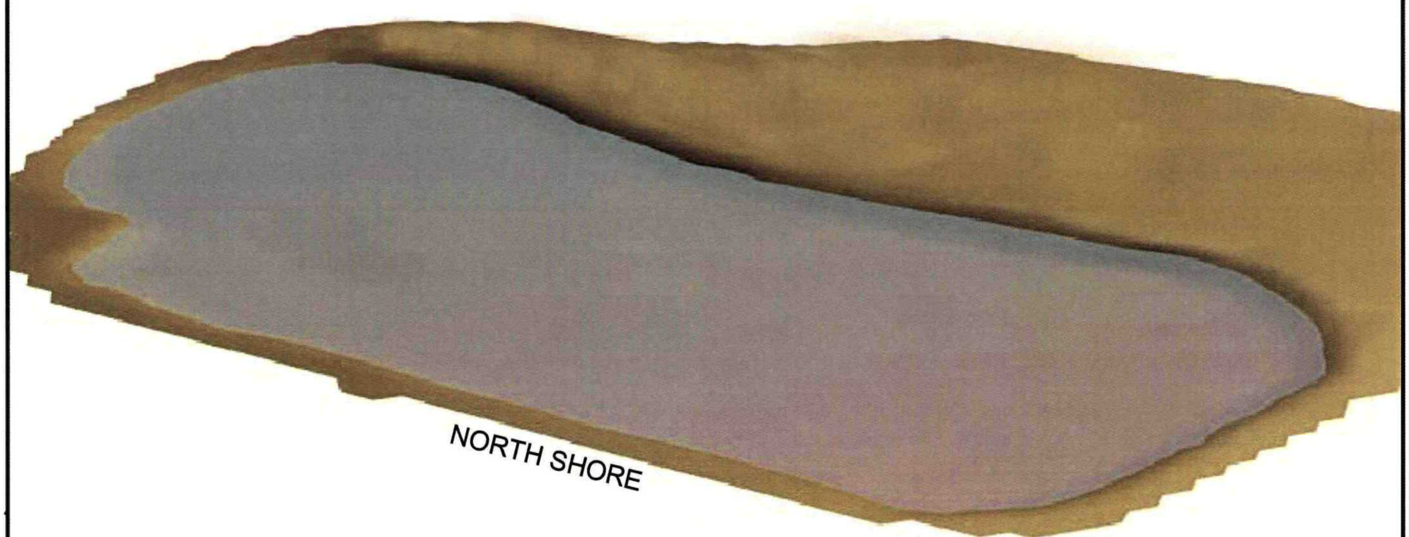
As shown in Figure 10-1, Phase 2 will supplement established native and naturalized vegetative communities that are developing along the 10- to 15-foot wide perimeter of Lower Lake and northern portions of the Upper Lake shoreline. This will involve grading and reshaping of the shoreline and capping with suitable cover soil. The material removed from the grading and reshaping of the shoreline will be integrated under the multi-layered cover system. In addition to supplementation of natural vegetation, fill will be added to portions of the Lower Lake perimeter to create an irregular, sinuous shoreline and introduce new wetland and wildlife habitat while potentially improving water quality. A tree and shrub screen similar to that established along the western shoreline of Lower Lake in 1997 will be planted along a northwestern portion of the Upper Lake shoreline. The permanent site security fence will be constructed along this screen to supplement the vegetative barrier between the cover system and Upper Lake.

10.2.1 Earthwork and Shoreline Improvements

To ensure the success of revegetation efforts, site conditions that have precluded the establishment of vegetation on barren shoreline locations will be identified. Shoreline bank slopes will be reduced where slopes exceed 3:1 in steepness. Field stone and gravel will be placed into Lower Lake to contour the lake shoreline, creating shelter and shallows (Figure 10-5). Shoreline areas will be capped to within 12 to 18 inches of the water line with suitable coversoil. Coversoil suitability criteria are presented in Table 10-4. The shoreline area between the coversoil and water line will be armored with 12-inch nominal riprap to minimize erosion by wave action.



LOWER LAKE WITH SHORELINE IMPROVEMENTS



LOWER LAKE PRIOR TO SHORELINE IMPROVEMENTS

ASARCO EAST HELENA SMELTER COVER SYSTEM DESIGN	**EARTHWORK AND SHORELINE IMPROVEMENTS ON LOWER LAKE**	**FIGURE** **10-5**

UPDATE TIME: 9:10AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H022.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

TABLE 10-4. COVERSOIL SUITABILITY CRITERIA

Parameter	Suitable Standard
pH	5.5 - 8.5
Electrical Conductivity	< 4 mmhos / cm
Sodium Adsorption Ratio	< 12
Acid-Base Potential	> -5 T / 1000T
C:N Ratio	< 20 : 1
Soil N	> 15 ug NO_3-N / g
Soil P	> 10 ug P / g (Bray extraction)
Soil K	> 75 ug K / g
Organic Matter	1 - 10 %
Saturation %	20 - 80 %
% Coarse Fragment Content	< 20 %
Texture	Loam Silt loam (sand > 15 %) Silty clay loam (clay < 35 %, sand > 15 %) Clay loam (clay < 35 %) Sandy clay loam Sandy loam

10.2.2 Revegetation of Shoreline Areas

The focus of revegetation efforts will be to supplement established native and naturalized vegetative communities that have developed along the 10- to 15-foot wide perimeter of Lower Lake and parts of Upper Lake north and west shorelines. Revegetation will result in the establishment of sustainable vegetative communities that are comparable to adjacent, undisturbed communities in the Upper Lake area. A preliminary inspection of the area in January 1997 (Hydrometrics, 1997) identified wetland and riparian habitats that may be used as a reference area for revegetation planning and success quantification. Habitats and vegetation species observed during the preliminary inspection are listed in Table 10-5.

TABLE 10-5. WETLAND/RIPARIAN HABITATS AND VEGETATION SPECIES OBSERVED IN THE UPPER LAKE AREA, JANUARY 1997

Scrub-Shrub Wetland	
Willow	*Salix spp.*
Alder	*Alnus spp.*
Red-twig dogwood	*Cornus stolonifera*
Reed canary grass	*Phalaris arundinacea*
Western wheatgrass	*Agropyron smithii*

Emergent Wetland	
Cattail	*Typha latifolia*
Reed canary grass	*Phalaris arundinacea*
Giant wildrye	*Elymus cinereus*

Mesic Shrub	
Willow	*Salix spp.*
Alder	*Alnus spp.*
Russian Olive	*Elaeagnus angustifolia*
Boxelder	*Acer negundo*
Woods rose	*Rosa woodsii*
Red-twig dogwood	*Cornus stolonifera*
Western wheatgrass	*Agropyron smithii*

To ensure revegetation success and ecosystem continuity, selected Upper Lake wetland/riparian vegetation communities will be utilized as sources for vegetative transplants (cuttings and live clumps) to SEP locations at Upper and Lower Lake shoreline sites. These transplants will be collected on a low-density, dispersed basis (minimum of 15 feet between collections) throughout accessible portions of the Upper Lake area. Sites that are disturbed by these collection activities will be graded and seeded with annual rye and western wheatgrass. These grasses will provide interim cover for natural regeneration. Establishment of vegetation on remaining shoreline areas will be accomplished through seeding and transplanting using commercial Montana seed/nursery sources. To increase diversity and further enhance wildlife habitat, native plant species listed in Table 10-6 may be used along Upper and Lower Lake shorelines.

TABLE 10-6. ADDITIONAL NATIVE PLANT SPECIES PROPOSED FOR ESTABLISHMENT IN UPPER AND LOWER LAKE WETLAND/RIPARIAN HABITATS

Scrub-Shrub Wetland	
Black cottonwood	*Populus trichocarpa*
Douglas hawthorn	*Crataegus douglasii*
Tufted hairgrass	*Deschampsia caespitosa*
Emergent Wetland	
Sedge	*Carex spp.*
Rush	*Juncus spp.*
Bulrush	*Scirpus spp.*
Arrowhead	*Sagittaria spp.*
Mesic Shrub	
Snowberry	*Symphoricarpos albus*
Serviceberry	*Amelanchier alnifolia*
Douglas hawthorn	*Crataegus douglasii*
Tufted hairgrass	*Deschampsia caespitosa*

10.3 PHASE 3

As shown in Figure 10-6, Phase 3 will establish an upland vegetative community in the area between Upper and Lower Lakes. This will involve covering the area with suitable coversoil (see Table 10-1) prior to revegetation with grasses. Revegetation activities will include the introduction of a sensitive plant species (lesser rushy milkvetch) at selected site locations to expand the range and population of this species. Trees and shrubs will be added along riparian fringe locations to enhance the quality of the upland habitat.

10.3.1 Earthwork and Upland Improvements

Fill will be used as needed to raise the area between the lakes and will be graded to improve its upland features and to promote drainage off the multi-layered cover system. Naturalized topography that enhances upland habitat for vegetation and wildlife between Upper and

ASARCO EAST HELENA SMELTER
COVER SYSTEM DESIGN

UPLAND AREA ENHANCEMENTS

FIGURE 10-6

UPDATE TIME: 11:38AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H023.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

Lower Lake will be accomplished by increasing the amount of common borrow on top of the liner. The area will then be covered with six inches of topsoil and revegetated.

10.3.2 Revegetation of Upland Areas

Revegetation of the area between the lakes will create a foothill grassland community comparable to established communities of this type in the East Helena area. Blending of this upland area into the planned Upper and Lower Lake wetland/riparian communities will create wildlife habitat opportunities. A preliminary inspection of the area in January 1997 (Hydrometrics, 1997a) identified occurrences of upland habitat that could be used as reference areas for revegetation planning and success quantification. These habitat and vegetation species, observed at several locations during the preliminary inspection, are listed in Table 10-7.

TABLE 10-7. UPLAND HABITAT AND VEGETATION SPECIES OBSERVED IN THE EAST HELENA AREA, 1997

Foothill Grassland	
Bluebunch wheatgrass	*Pseudoroegneria spicata*
Thickspike wheatgrass	*Agropyron dasystachyum*
Blue grama	*Bouteloua gracilis*
Idaho fescue	*Festuca idahoensis*
Needle-and-thread grass	*Stipa comata*
Sunflower	*Helianthus annuus*
Yarrow	*Achillea millefolium*

Revegetation of the area between the lakes will be accomplished through seeding and transplanting using commercial Montana seed/nursery sources. Additional native plant species are proposed for introduction to the area community in order to increase diversity and further enhance wildlife habitat. Native species under preliminary consideration are listed in Table 10-8.

TABLE 10-8. ADDITIONAL NATIVE PLANT SPECIES PROPOSED FOR UPLAND HABITAT ESTABLISHMENT IN THE AREA BETWEEN UPPER AND LOWER LAKES

Foothill Grassland	
Rough fescue	*Festuca scabrella*
Sandberg bluegrass	*Poa sandbergii*
Prairie coneflower	*Ratibida columnifera*
Lesser rushy milkvetch	*Astragalus convallarius*

The introduction of lesser rushy milkvetch will serve to expand the range and population of this species in the East Helena valley to which it is endemic. Lesser rushy milkvetch is classified by the Montana Natural Heritage Program (Lesica and Shelly, 1991) as a sensitive species. This plant has no statutory federal or state protection (Lesica and Shelly, 1991). Establishment of a population of lesser rushy milkvetch will be conducted as a trial introduction, pending input from appropriate resource organizations (state/federal agencies, the Montana Natural Heritage Program and the Montana Native Plant Society) and the successful location/propagation of this species.

10.3.3 Visual Screen

A shelterbelt planting of trees and shrubs will be installed along the riparian fringe at the west end of Lower Lake and along the northwest corner of Upper Lake. Shelterbelt species under consideration include box elder, Rocky Mountain juniper and Russian olive. The area will also be seeded to foothill grassland species (Table 10-7). The completion of this planting will result in a continuous row of trees and shrubs. Trees and shrubs creating a physical screen along the northwest side of Tito Park and Upper Lake were proposed in the SEP, but have been removed from this plan. The original intent of trees and shrubs as a physical screen was to block out noise from the operating plant. Due to the fact that a noise barrier is no longer necessary and plants on the cover system may compromise its integrity, these plants have been removed from the plan.

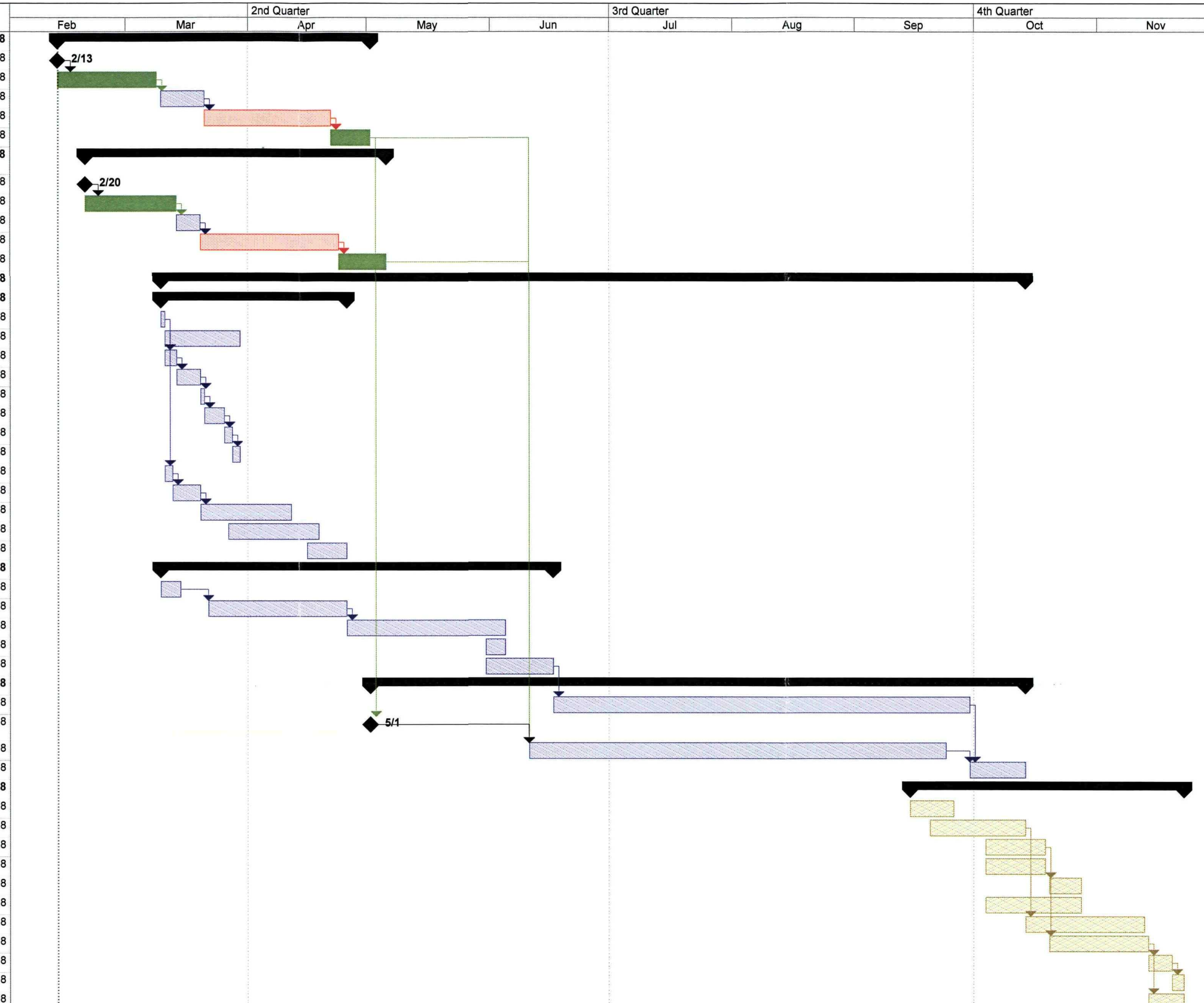
11.0 SCHEDULE

A schedule for implementing the Cover System for 2008 is dependent upon sequencing the: 1) soils sampling, excavation and confirmatory sampling for exposed areas, 2) demolition and soil sampling for the blast furnace and Monier flue, and 3) 2008 Montana cleaning and demolition program. The 2008 Cover System schedule is contained in Figure 11-1. Key schedule events include:

- Construction of the CAMU
- Pre-demolition Cleaning
- Demolition of structures
- Stack demolition
- Flue demolition
- Flue dust removal and associated impacted soils from exposed soil areas and
- Interim Cap.

FIGURE 11-1. COVER SYSTEM DESIGN SCHEDULE
ASARCO EAST HELENA SMELTER

ID	Task Name	Duration	Start	Finish
1	**Cover System Design**	**68 days**	**Wed 2/13/08**	**Thu 5/1/08**
2	Cover System Design to EPA	0 days	Wed 2/13/08	Wed 2/13/08
3	EPA Review and Comment	22 days	Wed 2/13/08	Sat 3/8/08
4	Response to Comments and Revisions	10 days	Mon 3/10/08	Thu 3/20/08
5	Public Comment	27 days	Fri 3/21/08	Mon 4/21/08
6	EPA Approval of Cover System Design	9 days	Tue 4/22/08	Thu 5/1/08
7	**Demo-Footprint Exposed Soil Sampling, Excavation and Demo Work Plan**	**65 days**	**Wed 2/20/08**	**Mon 5/5/08**
8	Report to EPA	0 days	Wed 2/20/08	Wed 2/20/08
9	EPA Review and Comment	20 days	Wed 2/20/08	Thu 3/13/08
10	Response to Comments and Revisions	5 days	Fri 3/14/08	Wed 3/19/08
11	Public Comment	30 days	Thu 3/20/08	Wed 4/23/08
12	EPA Approval of Sampling and Demolition Plan	10 days	Thu 4/24/08	Mon 5/5/08
13	**2008 Demo & CAMU Excavation**	**187 days**	**Mon 3/10/08**	**Mon 10/13/08**
14	**Phase I - CAMU Construction**	**41 days**	**Mon 3/10/08**	**Fri 4/25/08**
15	Mobilization (To Be Determined)	1 day	Mon 3/10/08	Mon 3/10/08
16	Roadway Construction and Paving	17 days	Tue 3/11/08	Sat 3/29/08
17	Strip Topsoil	3 days	Tue 3/11/08	Thu 3/13/08
18	Roadway Cuts/Fills	5 days	Fri 3/14/08	Wed 3/19/08
19	Install Culvert	1 day	Thu 3/20/08	Thu 3/20/08
20	Place Base Course	4 days	Fri 3/21/08	Tue 3/25/08
21	Build Gravel Access Road	2 days	Wed 3/26/08	Thu 3/27/08
22	Asphalt Paving	2 days	Fri 3/28/08	Sat 3/29/08
23	Install Silt Fence	2 days	Tue 3/11/08	Wed 3/12/08
24	Strip Topsoil	6 days	Thu 3/13/08	Wed 3/19/08
25	Excavation and Stockpile	20 days	Thu 3/20/08	Fri 4/11/08
26	Screen Clay Material	20 days	Thu 3/27/08	Fri 4/18/08
27	Install Compacted Clay Liner	9 days	Wed 4/16/08	Fri 4/25/08
28	**Phase II CAMU Construction**	**85 days**	**Mon 3/10/08**	**Mon 6/16/08**
29	Liner Submittals and Approvals	5 days	Mon 3/10/08	Fri 3/14/08
30	Order Liner Materials, Manufacturing, and Delivery	30 days	Sat 3/22/08	Fri 4/25/08
31	Liner Installation	34 days	Sat 4/26/08	Wed 6/4/08
32	Install Leachate Drainage System	4 days	Sat 5/31/08	Wed 6/4/08
33	Install Imported Cushion Material	14 days	Sat 5/31/08	Mon 6/16/08
34	**Phase III CAMU Operation and Site Demolition**	**141 days**	**Thu 5/1/08**	**Mon 10/13/08**
35	Waste Placement	90 days	Tue 6/17/08	Mon 9/29/08
36	Authorization to Start Demolition Project (no later than May 1)	0 days	Thu 5/1/08	Thu 5/1/08
37	2008 Demolition	90 days	Wed 6/11/08	Tue 9/23/08
38	CAMU Temporary Cover	12 days	Tue 9/30/08	Mon 10/13/08
39	**2008 Permanent Cover System Construction**	**60 days**	**Mon 9/15/08**	**Sat 11/22/08**
40	Subgrade Preparation; Grade & Compact Fill	10 days	Mon 9/15/08	Thu 9/25/08
41	Crush and Place Slag Fill Material	20 days	Sat 9/20/08	Mon 10/13/08
42	GCL Liner, Reinforced	13 days	Sat 10/4/08	Sat 10/18/08
43	40-mil PVC Liner	13 days	Sat 10/4/08	Sat 10/18/08
44	Drainage GeoNet	7 days	Mon 10/20/08	Mon 10/27/08
45	Liner Anchor System	20 days	Sat 10/4/08	Mon 10/27/08
46	Excavation & Stockpile of Soils	26 days	Tue 10/14/08	Wed 11/12/08
47	Load, Haul, Place & Compact Borrow Soil	22 days	Mon 10/20/08	Thu 11/13/08
48	Load, Haul, Place & Compact Top Soil	5 days	Fri 11/14/08	Wed 11/19/08
49	Seed, Fertilize & Mulch	3 days	Thu 11/20/08	Sat 11/22/08
50	Fence with Appurtenances	8 days	Fri 11/14/08	Sat 11/22/08



Project: Cover System Design
Date: Wed 2/13/08

Task		Progress		Summary		External Tasks		Deadline
Split		Milestone		Project Summary		External Milestone	

H:\FILES\007 ASARCO\7054\Cover System Design.mpp\HLN\02/13/08\065

12.0 REFERENCES

ASARCO, 2006. Storm Water Pollution Prevention Plan, ASARCO LLC, East Helena, Montana, September 2006.

ASARCO, 2007. Spill Prevention Control and Countermeasure Plan, 2007.

ASARCO, 2008. Demolition Foot Print Exposed Soil Area Sampling Excavation and Confirmatory Sampling Work Plan, 2008.

Asarco Consulting, Inc., 2003. Phase I RCRA Facility Investigation Site Characterization Report, East Helena Facility, February 2003, Revised 2005.

California Department of Transportation, 2000. California Bank and Shore Rock Slope Protection Design, October 2000.

Environmental Protection Agency, 1982. Evaluating Cover Systems for Solid and Hazardous Waste, September 1982.

Environmental Protection Agency, 1987. Design, Construction, and Maintenance of Cover Systems for Hazardous Waste and Engineering Guidance Document, November 1987.

Environmental Protection Agency, 1989. Record of Decision (ROD) – East Helena Smelter Site Process Ponds Operable Unit East Helena, Montana, U.S. EPA Region VIII, November, 1989.

Environmental Protection Agency, 1991. Design and Construction of RCRA/CERCLA Final Covers, May 1991.

Environmental Protection Agency, 1994. The Hydrologic Evaluation of Landfill Performance (HELP) Model, User's Guide for Version 3, September 1994.

Environmental Protection Agency, 2002. Reusing Superfund Sites: Commercial Use Where Waste is Left on Site", EPA 540-K-01-008, February 2002.

Environmental Protection Agency, 2007. EPA Announces Plans for Final Cleanup at East Helena's Residential Soils and Undeveloped Lands, January 2007.

Federal Emergency Management Agency, 1985. Flood Insurance Study, City of East Helena, Montana, Lewis and Clark County, September 27.

Federal Emergency Management Agency, Revised 2002. Flood Insurance Study, Lewis and Clark County, Montana, Unincorporated Areas, June 17.

GMT Consultants, 1991. Geotechnical Investigation, Proposed Scrubber Water Treatment Facility, ASARCO, Inc. Plant, East Helena, Montana, 1991.

Hunt, 1984. Geotechnical Engineering Investigation Manual, McGraw Hill, 1984.

Hydrometrics, Inc., 1990. Comprehensive Remedial Investigation/Feasibility Study, ASARCO, Inc., East Helena, Montana, January 1990.

Hydrometrics, Inc., 1997. Proposed Supplemental Project (SEP) For the ASARCO East Helena Plant, February 1997.

Hydrometrics, Inc., 1998. Current Conditions/Release Assessment, East Helena Facility, September 1998.

Hydrometrics, Inc., 1999. Interim Measures Work Plan, East Helena Facility, 1999.

Hydrometrics, Inc., 2000. RCRA Facility Investigation (RFI) Work Plan, 2000.

Hydrometrics, Inc., 2007a. 2007 Cleaning and Demolition Project, Asarco East Helena Plant, May 2007, Revised August 2007.

Hydrometrics, Inc., 2007b. Design Analysis Report, Asarco East Helena, Corrective Action Management Unit (CAMU) Phase 2 Cell, Revised October 2007.

Koerner, 1998. Designing With Geosysthetics, Prentice Hall, 1998.

National Oceanic and Atmospheric Administration. Precipitation – Frequency Atlas of the Western United States, Volume 1 – Montana, 1973.

Natural Resources and Conservation Service, 1971. SCS National Engineering Handbook, Section 4, Hydrology, U.S. Department of Agriculture, Soil Conservation Service, U.S. Government Printing Office, 1971.

U.S. Department of the Army, Corps of Engineers, 1995. Hydraulic Design of Flood Control Channels, Engineer Manual EM 1110-2-1601, 1995.

U.S. Department of the Army, Corps of Engineers, 2005. HEC-RAS River Analysis System, Generalized Computer Program. Hydrologic Engineering Center, Davis, California. May, 2005.

APPENDIX A

SPECIFICATIONS

PROJECT SPECIFICATIONS

The Standard Specifications for Road and Bridge Construction, edition of 2006, prepared by the Montana Department of Transportation and Montana Transportation Commission, hereinafter referred to as the "Standard Specifications," shall be applied to Project work as specified below and shall govern this Project and form the basis of this Contract, except as modified in these Contract Documents. Contractor shall note the 2006 Standard Specifications shall be used as modified herein without subsequent amendments or newer publications made by the Montana Department of Transportation and Montana Transportation Commission. The Standard Specifications are modified herein as detailed in the following divisions. Division and subdivision numbers refer to corresponding numbers of the Standard Specifications. Additional division or sections numbers may be used to specify items of work not included in the Standard Specifications.

Copies of the 2006 Standard Specifications may be obtained from Montana Department of Transportation, Contract Plans Section, 2701 Prospect Avenue, P.O. Box 201001, Helena, Montana 59620-1001, Telephone (406) 444-6215 or at www.mdt.mt.gov/business/contracting /standard_specs.shtml

DIVISION 200 - EARTHWORK
DIVISION 600 - MISCELLANEOUS CONSTRUCTION
DIVISION 700 - MATERIALS

DIVISION 200 – EARTHWORK

SECTION 203 - EXCAVATION AND EMBANKMENT:

Add the following subsections to this section.

203.06 DESCRIPTION OF PROJECT EARTHWORK

This specification covers the requirements for labor, supervision, equipment and materials associated with the earthwork operations shown on or implied by the design Drawings, or herein specified. Earthwork activities shall include, but not be limited to project layout, soil testing, site drainage, dust control, clearing, disposal, excavation, subgrade preparation, protection and removal of known underground utilities, fill and backfill, embankments, finish grading and site restoration.

203.07 CONSTRUCTION REQUIREMENTS OF PROJECT EARTHWORK

203.07.1 Grade Control and Layout of Work

The Contractor shall furnish all stakes, markers, tools, equipment and labor required to lay out the work from bench marks and/or control point markers indicated on the drawings. The Contractor shall not disturb existing survey monuments or bench marks without the consent of the Engineer. Markers that are accidentally disturbed by earthwork operations shall be replaced at the Contractor's expense by a licensed land surveyor. Copies of all survey notes will be given to the Engineer within one day after survey is conducted. Restaking and remarking of layout stakes caused by misinterpretation of the specifications will be at the Contractor's expense. It is recommended that the surveyor meet with the Engineer to review grades and dimensions, prior to commencing layout surveys.

203.07.2 Inspection and Testing

The Owner may employ independent engineering firms for Quality Assurance inspection and testing. Contractor shall cooperate with the Owner's oversight personnel. The Owner will pay for Quality Assurance testing. However, if initial testing indicates that the Contractor has not complied with the Contract Documents, then the costs of subsequent testing associated with the non-compliance will be deducted from the Contract price.

The Contractor is required to conduct Quality Control testing. Costs for these tests will be paid by the Contractor.

203.07.3 Protection and Safety

Open Excavations. Provide barricades and/or other safety equipment as required to protect any equipment, vehicles and workers from any open excavation.

A. Protection of Property. The Contractor shall protect adjacent property and avoid damage to such property. Adjacent property damaged due to the Contractor's operations shall be repaired or replaced. The repairs and/or replacement shall be equal to existing improvements and shall match existing finish and dimensions.

B. Utilities. The Contractor is responsible for obtaining off-site utility locations as required by law. He will notify the Engineer prior to digging adjacent to utilities.

203.07.4 Subgrade and Fill Protection

During construction, fills and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained in such a manner as to drain effectively at all times.

Finished subgrade shall not be disturbed by traffic or other operations and shall be protected and maintained by the Contractor until completion and acceptance of the work. The storage or stockpiling of materials on the finished subgrade will not be permitted.

203.07.5 Site Drainage

Excavation, fill and backfill work areas shall be continually and effectively drained. Water shall not be permitted to accumulate in excavations or foundation areas. The Contractor shall construct suitable dikes, drains or provide pumping equipment, as required, to divert water flows away from the work areas.

203.07.6 Dust Control and Haul Road Maintenance

Control all dust produced from the project site. Prevent the spread of dust and avoid creation of a nuisance in the surrounding area. The Contractor shall prepare and submit a Dust Control Plan to the Owner for approval before construction begins. The Dust Control Plan will address methods to be used to minimize dust during sodding, hauling waste placement, grading and earthwork operations. It will also describe haul road sweeping and maintenance operations.

203.07.7 Excavation

A. General Requirements. The Contractor shall excavate every type of material encountered within the limits of the project, to the lines, grades and elevations indicated and as specified herein.

B. Excavations for Ditches and Drainage Structures. Excavations for ditches and drainage structures shall be accomplished by cutting accurately the line, grade and cross-section required. Trenches and pits shall be of sufficient size to accommodate the installation of piping and structures. Excessive open ditch excavation shall be backfilled with satisfactory materials to the grades shown on the design Drawings. The Contractor shall maintain all excavations free from detrimental quantities of brush, sticks, trash and other debris.

C. Subgrade Preparations

1. **General Requirements.** Subgrade shall be shaped to the line, grade and cross-section and compacted as specified for all required embankments. This operation shall include plowing, disking and any moistening or aeration required to obtain proper compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory material as directed by the Engineer.

   Low areas resulting from the removal of unsatisfactory material shall be brought up to the required grade with satisfactory materials, and the entire subgrade shall be shaped to the line, grade and cross-section and compacted as specified.

   After rolling, the elevation of the finished subgrade shall not vary more than 0.2 foot from the established grade and approved cross-section.

2. **Compaction.** Compaction shall be accomplished by sheepsfoot rollers to at least 90 percent of Proctor maximum dry density.

203.07.8 Embankment

A. Materials

1. **Compacted Slag.** Compacted slag shall be placed between the installed cover systems and the plant site ground surface to promote drainage of the liner system. The compacted slag material shall vary in depth throughout the site and act as a cushion material. At a minimum, the top 6" shall be ripped slag.

2. **Excavated Soils.** Soils removed from the soil removal area of the plant will be used as backfill materials.

3. **Topsoil and Subsoil.** The Contractor shall obtain topsoil and subsoil from clean sources. Topsoil shall be free of trash, rocks, hard lumps of soil, and stubble. Subsoil shall be free of sharp or jagged rocks, roots, and debris.

B. Compaction

1. **Compacted Slag and Excavated Soils.** The Contractor shall compact the crushed slag by rolling using vibratory compaction equipment with a static weight of 15 tons. Two coverages shall be completed for each 12-inch lift.

2. **Subsoil.** The Contractor shall lightly roll the subsoil using nonvibratory compaction equipment with a static weight of 1.5 tons or less to ensure its stability under equipment traffic. Carefully roll the layer under the guidance of the Engineer to ensure that the underlying flexible membrane liner is not damaged.

D. Finish Grading

The surface of all excavation, fill, embankment and subgrade shall be finished to a reasonable smooth and compact surface in accordance with the lines, grades and cross-sections shown. The degree of finish for all graded areas shall be within 0.2 foot of the grades and elevations indicated. Gutters and ditches shall be finished in manner that will result in effective drainage.

203.07.9 Monitoring Wells

All monitoring wells shall be protected at all times and shall not be damaged during construction. Contractor shall be responsible to reimburse the Owner should well replacement be necessary due to Contractor activities. All well extensions and completions shall be vertical and maintain the integrity of the existing PVC casing. All well extensions shall be done by a licensed monitoring well constructor is accordance with Montana Department of Natural Resources and Conservation (MDNRC) monitoring well construction requirements. Extended wells must be surveyed in by a licensed surveyor to determine the new casing elevation.

END OF SECTION

DIVISION 600

MISCELLANEOUS CONSTRUCTION

SECTION 613 RIPRAP AND SLOPE AND BANK PROTECTION

613.02 MATERIALS

Replace with the following paragraph.

Furnish stone that is hard, durable, sound, angular in shape, resistant to weathering and to water action; free from overburden, spoil, shale, structural defects, and organic material. The least or nominal dimensions of any stone shall not be less than 1/3 its greatest dimension. Unless otherwise permitted, the bulk density of the stone shall be 165 pounds per cubic foot, with a specific gravity of 2.65. All stone shall meet specifications for limits of total metals.

GRADATIONS

Stone materials shall meet the following gradation requirements:

Sieve Designation	Percent Passing
15-inch	95-100
12-inch	40-60
8-inch	0-10

This gradation may be adjusted only with approval of the Owner's Representative.

TOTAL METALS SAMPLING

All stone sources shall be shown to be free of deleterious amounts of heavy metals through sampling and analysis for heavy metals. Two totals metals samples shall be collected from each separate stone source and submitted for total metals laboratory analysis. The concentrations of the following elements shall be determined: arsenic, cadmium, copper, lead, mercury, and zinc.

Element	Total Concentration (milligrams per kilogram)
Arsenic	30
Cadmium	4
Copper	100
Lead	100
Mercury	5
Zinc	250

Sample results shall be submitted to the Owner's Representative and approved by the Owner's Representative before any rock is brought to the site. If concentrations greater than the above levels are found, the material shall be rejected and another rock source shall be found and tested for acceptance.

PLACING

Rock slope protection shall be placed in accordance with the following method:
A footing trench shall be excavated along the toe of the slope as shown on the plans. Rocks shall be so placed as to provide a minimum of voids and the larger rocks shall be placed in the toe course and on the outside surface of the slope protection. The rock may be placed by dumping and may be spread in layers by bulldozers or other suitable equipment. Local surface irregularities of the slope protection shall not vary from the planned slopes by more than 0.3-m measured at right angles to the slope. At the completion of slope protection work, the footing trench shall be filled with excavated material and compaction will not be required.

SECTION 622 GEOSYNTHETICS CONSTRUCTION

622.01 MATERIALS

Replace with the following paragraph.

Furnish materials meeting the following requirements:

Geotextiles	Subsection 716.01
Geomembranes	Section 624
Geocomposite	Section 625
GCL	Section 626

SECTION 624 FLEXIBLE MEMBRANE LINER (FML)

Add the following new section.

624.01 DESCRIPTION

A. Scope. The work covered by these Specifications consists of furnishing and installing a polyvinyl chloride (PVC) flexible membrane liner where shown on the Drawings.

B. Definitions used in this section.

1. **Air Lance**. Consists of a stream of air forced through a 3/32" air nozzle at the end of a hollow metal tube for conducting a commonly used nondestructive test method to determine seam continuity and tightness of relatively thin, flexible geomembrane.

2. **Bodied Chemical Fusion Agent**. A chemical fluid containing a portion of the parent geomembrane that, after application of pressure and after the passage of time, results in the chemical fusion of two essentially similar geomembrane sheets, leaving behind only that portion of the parent material.

3. **Geomembrane**. An essentially impermeable synthetic membrane used as a solid or liquid barrier. Synonymous term for flexible membrane liner (FML).

4. **Seaming Boards.** Smooth wooden boards, conveyor belt, or similar hard surface (preferably 1" X 12" X 8', or more), placed beneath the area to be seamed to provide a uniform surface to apply roller pressure in the fabrication of field seams.

5. **Tensiometer.** A device containing a set of opposing grips used to place a geomembrane seam in tension for evaluating its strength in shear or in peel.

6. **Vacuum Box Assembly.** Consists of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, or valve assembly, and a vacuum gauge for conducting a nondestructive test method which develops a vacuum in a localized region of a geomembrane seam in order to evaluate the seam's tightness and suitability.

624.02 QUALITY ASSURANCE

A. Fabricator/Installer Qualifications

1. The installer shall have worked in a similar capacity on at least five (5) projects similar in complexity to the project described in the Contract Documents and with each project involving at least 100,000 square feet of a similar product.

2. Installation supervisor/field engineer shall have worked in a similar capacity on at least two (2) jobs similar in size and complexity to the project described in the Contract Documents.

3. The manufacturer shall perform the quality control tests listed in Table 4 at the manufacturing plant. Provide all quality control certificate to the Engineer as specified in Section 624.03(B) of these Special Provisions.

TABLE 4. GEOMEMBRANE SPECIFICATIONS

PROPERTY	TEST METHOD	REQUIREMENT
		CAP
Gauge (mils nominal)	ASTM D 1593	40
Tear Strength (pounds)	ASTM D 1004 or ASTM D 751	10
Tensile Strength 1. Machine direction (lb/in) 2. Cross-machine direction (lb/in)	ASTM D 882	 97 97
Hydrostatic Resistance (lb/in^2)	ASTM D 751	120

B. Delivery, Storage and Handling

1. Deliver geomembrane to the site only after the Engineer receives and approves the required submittals. Immediately remove damaged or unacceptable material from the site and replaced at no cost to the Owner.

2. Store geomembrane on pallets to protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, direct heat of the sun or other damage. Stack geomembrane no more than 3 rolls or 1 pallet high.

3. Repair all geomembrane damaged during handling to the satisfaction of the Engineer. Immediately remove from the site and replace geomembrane determined by the Engineer to be irreparably damaged. Repair, removal and replacement shall be solely at the Contractor's expense.

C. Warranty

1. The geomembrane installer shall warrant his workmanship to be free of defects for one (1) year after final acceptance of the work. This warranty shall include, but not be limited to, all seams, anchor trenches, geomembrane attachments to appurtenances, and penetration seals. The installer shall also obtain and furnish the Owner a material warranty from the geomembrane manufacturer. The material warranty shall be for defects or failure due to weathering for ten (10) years after final acceptance.

2. Should a defect or failure occur within the aforesaid periods, the installer shall bear all costs for repair and/or replacement of the geomembrane and shall in addition bear all costs for the excavation of any cover backfill that is required to be removed in order to repair and/or replace the geomembrane. All materials removed to allow repairs to be made shall be reinstalled by the installer in accordance with these Contract Documents.

624.03 SUBMITTALS

A. Submit the following documents to the Engineer no later than three (3) weeks prior to installation of the geomembrane:

1. Complete written instructions for storage, handling, installation and seaming of the geomembrane which are in compliance with the Specifications and conditions of warranty.

2. Panel layout drawings showing both fabricated and field seams, and details not conforming with the Drawings (if any).

3. Qualification of the geomembrane installer, including the resume of the field engineer installation supervisor to be assigned to this project, including dates and duration of employment.

4. Installer's Quality Control Manual.

B. Submit the following documents to the Engineer prior to the shipment of the geomembrane to the site.

1. Polymer compound data

a) Statement of production date or dates.
b) Laboratory certification that the materials meet Specifications.
c) Certification that all materials are from the same manufacturer.
d) Copy of quality control certificates issued by manufacturer.
e) Statement that no reclaimed polymer is added to the compound.

2. Geomembrane data.

a) Statement of production date or dates
b) Laboratory certification that the materials meet the Specification.
c) Copy of quality control certificates issued by the manufacturer.
d) Reports of tests defined in Table 5-1 from the manufacturer.

TABLE 5-1. MANUFACTURER'S QA TESTS FOR FML

Property	Test Method	Test Frequency	Test Standard(1) PVC 40 mil	Rejection Criteria
Gauge (mils nominal)	ASTM D 1593	1 per lot	40	Material must meet all standards before delivery to site
Tear Strength (pounds)	ASTM D 1004		10	
Tensile Strength 3. Machine direction (lb/in) 4. Cross-machine direction (lb/in)	ASTM D 882		 97 97	
Hydrostatic Resistance (lb/in^2)	ASTM D 751		120	
Specific Gravity	ASTM D 792		≥1.2	

Notes:
(1) Values shown are minimum average roll values.

C. Submit the following to the Engineer prior to start of the FML installation:

1. Warranties for material and installation as specified hereinafter for review to the Owner.

2. Certificate of acceptance of prepared subgrade for each area to be covered by an PVC FML, signed by the installation supervisor.

D. During installation, submit to the Engineer results of Contractor quality control testing as specified in 624.06 TESTING.

E. Upon completion of the installation, submit to the Engineer the following:

1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents.

2. Manufacturer's and Installer's warranties as specified hereinafter.

3. Record drawings showing location of panels, seams, repairs, patches, and destructive samples, including detailed measurements.

624.04 MATERIALS

A. Description of Materials

1. Geomembrane liner shall be top quality products, recommended by the manufacturer for this specific type of work, and shall have been satisfactorily demonstrated by prior use to be suitable and durable for such purposes.

2. Extrudate Rod or Bead shall be made from the same resin as the geomembrane liner with carbon black. Additives shall be thoroughly dispersed in the extrudate.

B. Physical Characteristics

The PVC geomembrane liner:

1. Shall be formulated from a polyvinyl chloride resin with a specific gravity greater than or equal to 1.2. All resins shall be of the same type and no batch shall be blended with recycles or seconds.

2. Shall be uniform in color, thickness, and size. The material shall be a flexible, durable, watertight product free of pinholes, blisters, holes, bubbles, gels, undispersed resins or carbon black, and other contaminants. Processing aides, antioxidants and other additives shall not exceed a combined maximum total of 1 percent by weight, ignoring carbon black, and 3.5 percent by weight including carbon black.

3. Shall have the minimum physical property characteristics, as outlined in Table 4. Certified test results showing that the sheeting meets or exceeds the Specification shall be submitted per Section 624.03.

4. Shall be supplied in rolls labeled with thickness, length, width, manufacturer, plant location, and identification number.

624.05 INSTALLATION

A. Subgrade Preparation

The subgrade to be lined:

1. Shall be maintained in a dry enough condition for equipment to operate without rutting.

2. Shall be smooth and free of projections and sharp objects that can damage the lining. Remove rocks, hard clods, and other such material, and roll the subgrade so as to provide a smooth compact surface. The smoothed subgrade will limit liner bridging to less than 1 inch.

3. Shall be inspected prior to geomembrane installation to ascertain its suitability for installation in compliance with the terms of the product warranty and the requirements of this Specification. For PVC geomembranes, submit to the Engineer a signed certification that the prepared subgrade surface is satisfactory. Installation of geomembrane without providing written certification shall constitute acceptance of the subgrade by the Contractor.

4. Shall have round edges at anchor trenches or edges shall be cushioned with geotextile and backfill.

B. Geomembrane Installation

1. Only layout the amount of geomembrane that can be seamed during that same day. Assign each panel a simple and logical identifying code number or letter. For PVC geomembrane, identify the panels with each appropriate code on the layout design referenced in 624.03 A.2.

2. Do not damage geomembrane by handling, traffic, or leakage of hydrocarbons or any other means. Do not wear damaging shoes or engage in activities that could damage the geomembrane. Open or unroll geomembrane panels using methods that will not damage, stretch or crimp the geomembrane. Prevent excess condensation on the geomembrane such that the underlying surface is not adversely impacted. Protect underlying surface from damage. Provide sufficient material to allow for geomembrane shrinkage and contraction. Use methods that minimize wrinkles between adjacent panels. Place ballast on geomembrane to prevent uplift from wind. Use ballast that will not damage geomembrane. Do not allow vehicle traffic directly on geomembrane. Remove folded or wrinkled material that exceeds 6 inches in width. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for testing and/or repair. Any portion of the lining damaged during installation shall be removed or repaired by using an additional piece of the same membrane as specified herein. The liner shall be installed in a relaxed condition and shall be free of stress or tension upon completion of the installation. Stretching the liner to fit is not

permissible. Backfill anchor trenches as soon as possible after installation of liner and geocomposite, if applicable.

3. Place and seam geomembrane only when ambient temperatures, measured six inches above the geomembrane, are between 40 degrees F and 100 degrees F, unless otherwise specified or approved. Installation below 40 degrees F shall occur only after verifying that the geomembrane can be seamed according to Specifications and approval by the Engineer. Do not install geomembrane during precipitation, in the presence of excessive moisture, in areas of ponded water, or in the presence of excessive winds. Protect the geomembrane from wind uplift during installation through the use of sand bags or other suitable weights.

4. Repair all damaged geomembrane and test damaged areas prior to backfilling.

C. Pipe Boots. Fit and seal pipes, manholes, and other penetrations of the geomembrane with shop fabricated boots as shown on the Drawings. Match the flange portion of the boot to the angle of the slope or bottom where the pipe or manhole enters the liner for a smooth fit without excess stretching of the material.

D. Seaming

1. Seam Layout shall:

   a) Orient seams parallel to line of maximum slope, i.e., orient down, not across, slope.
   b) Keep butt seams at least ten (10) feet horizontally away from toe of slope.
   c) For PVC geomembrane, use seam numbering system compatible with panel numbering system.

2. Trial field seaming shall be accomplished by the Contractor on-site for PVC FMLs.

   a) Conduct trial seams on pieces of geomembrane to verify adequate seaming methods and conditions.

   b) Conduct trial seams:

      1) At beginning of each seaming period;
      2) At least once for each four seaming hours;
      3) For each seaming apparatus in use;
      4) At least once per shift for each person performing seaming; and
      5) Whenever changes in climatic conditions could effect seam quality.

   c) Make test seam in the location of seaming and in contact with subgrade or geosynthetic (same condition as the geomembrane to be seamed).

d) Make test seam sample at least two (2) feet long and eleven (11) inches wide with the seam centered lengthwise.

e) Cut two, 1-inch wide test strips from opposite ends of the trial seams.

f) Cut specimens constant 1-inch wide and clamp at 90 degree angle in tensiometer.

g) Quantitatively test field specimens for peel adhesion (ASTM D3083) first, and bonded seam strength (ASTM 3083) second. Insure that these tests are performed in this order.

h) A trial seam sample passes when the following results are achieved for both tests.

   1) The break is film tearing bond (FTB);
   2) The break is ductile; and
   3) The strength of break is at least 80% of the specified sheet strength.

i) Repeat the trial seam in its entirety if one (1) of the trial seam samples fails in either peel or shear mode.

j) Notify Engineer when repeated trial seam fails and do not continue seaming until deficiencies or adverse conditions are determined and corrected, and two (2) consecutive successful trial seams are achieved.

3. Use the following seaming procedure for PVC geomembranes.

   a) Do not begin seaming on liner until all trial seam test samples made by the equipment to be used passes tests as defined above.

   b) Form seams per manufacturers written instructions. Wipe the contact surfaces of the panels clean to remove all dirt, dust or other substance. Use solvent for cleaning contact surfaces of field joints and for other required uses as recommended by the manufacturer. Apply a hot wedge or hot knife seaming tool to the overlapped panel edges creating a continuous thermal bond between the panels. Smooth out any wrinkles. Field seams shall have a strength of at least 80% of the specified sheet strength.

   c) Extend seaming to the outside edge of panels to be placed under the anchor berm and in the anchor trench.

   d) If there is not firm substrate, use a seaming board directly under the seam overlap to achieve proper support.

   e) If seaming operations are carried out at night, provide adequate illumination.

f) Cut fish mouths or wrinkles at the seam overlaps along the ridge of the wrinkle in order to achieve a flat overlap. Seam the cut fish mouths or wrinkles and patch any portion where the overlap is less than three (3) inches with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.

g) Seam only when ambient temperature, measured 6 inches above the geomembrane is between 40 degrees F and 100 degrees F unless other limits are accepted, in writing, by the Engineer.

E. Defects and Repairs

1. Inspection

a) During installation and seaming, visually examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of the examination. Mark areas suspected of deficiencies. Remove areas of geomembrane requiring more than one patch per 5,000 square feet and replace at no additional cost to the Owner.

b) Repair each suspect location both in seam and non-seam areas shall be repaired and non-destructively tested. Do not proceed with work which will cover locations which have been repaired until passing test results are achieved.

2. Repair Procedures

a) Repair all portions of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. Provide a written recommendation for method of repair to the Engineer prior to initiating repair and obtain approval of the repair procedure from the Engineer prior to making repair. Methods which are acceptable to the Engineer and their application are as follows:

1) Capping. Cap for repair of large lengths of failed seams.
2) Patching. Patch large (over 3/8 inch diameter) holes, tears (over 2 inches long), undispersed raw material, and contamination by foreign matter.
3) Remove and Replace. Remove the unsatisfactory material and replace with new material seamed into place.

b) In addition

1) Abrade surfaces of the geomembrane which need repaired no more than one-half (1/2) hour prior to the repair.
2) Clean and dry all surfaces at the time of repair.

3) Extend patches or caps at least six (6) inches beyond the edge of the defect and all corners of patches shall be rounded with a radius of at least three (3) inches.
4) Cut the geomembrane below large caps to avoid water or gas collection between the sheets.

c) Nondestructively test each repair using the methods described in Section 624.06 of these Special Provisions. Repairs which pass the non-destructive test shall be considered an adequate repair. Large caps shall be of sufficient length to require destructive test sampling, at the discretion of the Engineer. Redo repairs that have failed tests and retest until a passing test results.

624.06 TESTING

A. General

1. Quality control testing, including laboratory testing, field seam testing, and destructive testing in accordance with Table 5-2 shall be performed by the Contractor and observed at the discretion by the Engineer.

2. PVC field seams shall be non-destructively tested over their full length by pressurizing the seam for dual-hot-wedge method seams in the PVC geomembranes, or using a vacuum test unit, air lance, or other approved method for seams in PVC geomembranes where the dual-hot-wedge method could not be used. Non-destructive testing shall be carried out as the seaming progresses, not at the completion of all the field seaming.

B. Vacuum Testing

1. The equipment shall consist of the following:

   a) A vacuum box assembly.

   b) A steel vacuum tank and pump assembly equipped with a pressure control and pipe connections.

   c) A rubber pressure/vacuum hose with fittings and connections.

   d) A soapy solution and applicator.

2. The following procedures shall be followed:

   a) Energize the vacuum pump and reduce the tank pressure to approximately ten (10) inches of water.

   b) Place the box over the wetted seam area (soapy solution).

TABLE 5-2. QUALITY CONTROL CRITERIA FOR FML

Parameter	Test Method	Frequency	Standard	Test Rejection Criteria
Surface Conditions	Visual Inspection	100%	No holes, ridges, voids, rocks, roots, ruts or other non-conformities	Reject and replace all surfaces with any of the items at left
Anchor Trenches	Visual/Tape Measure	100%	See dimensions on project plans	Reject and repair all non-conforming trenches
FML Placement	Visual	100%		Reject and replace non-conforming panels
Seaming	Visual	100%		
Seam Tensile Strength	ASTM D-638	1 per 500 feet of seam	Base material properties – see Table 5-1	Reject and replace non-conforming seams
Seam Shear & Peel	ASTM D-4437	1 per 500 feet of seam	Shear strength: 120 lb/in – 60 mil 80 lb/in – 40 mil Peel strength: 91 lb/in$^{(2)}$ – 60 mil 78 lb/in$^{(3)}$ – 60 mil 60 lb/in$^{(2)}$ – 40 mil 52 lb/in$^{(3)}$ – 40 mil	Reject and replace non-conforming seams
Trial Seam	ASTM D-3083	1) Beginning of each shift of seaming and every four hours thereafter 2) At any change in seam operator, equipment or weather	Break must be a ductile film tear with at least 80% of minimum sheet strength	Repeat trial seaming until standard is met
Air lance Vacuum Box or Internal Pressure	ASTM D-4437 ASTM D-4437 or As described in specifications	100%	Ripples or bubbles Bubbles emerging from seams Loss of pressure ≤4 psi in 7 minutes	Identify, repair and replace leaking seams

Notes:

(1) Hot wedge seams only

(2) Extrusion fillet weld only

c) Ensure that a leak-tight seal is created.

d) For a period of not less than fifteen (15) seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

e) All areas where soap bubbles appear shall be marked and repaired in accordance with repair procedures described in Section 624.05E.

f) Conduct vacuum testing per ASTM 4437.

C. Air Lance Testing

1. Equipment shall consist of an air lance that can provide a minimum air pressure of 30 psi and a maximum air pressure of 40 psi.

2. The following procedures shall be followed:

a) The air nozzle shall be held at a 45 degree angle to the field seam approximately 2" off the edge of the material.

b) The air shall be directed toward the seam edge, upper edge and surface to detect loose edges.

c) Riffles indicating unbonded areas within the seam or other undesirable seam conditions shall be patched in accordance with repair procedures described in Section 624.05 (E). The patch should then be tested using the same air lance test method.

d) Conduct air lance testing per ASTM 4437.

D. Destructive Testing of Seams in PVC FMLs

1. The Engineer will direct the Contractor to perform destructive seam tests at selected locations. The purpose of these tests is to evaluate seam strength. Perform seam strength testing as the seaming work progresses, not at the completion of all field seaming.

2. Location and Frequency

a) Collect destructive test samples shall be collected at a minimum frequency of one (1) test location per five hundred (500) feet of seam length, unless otherwise directed by the Engineer.

b) Samples, in addition to the minimum frequency, shall be taken as required by the Engineer.

c) Test location shall be determined during seaming and may be prompted by suspicion of insufficient adhesive, contamination, offsets, or any other potential cause of imperfect seaming. The Engineer will select the locations. The Engineer will not notify the Installer in advance of selecting locations where seam samples will be taken.

d) The Engineer reserves the right to increase the frequency in accordance with the actual performance results of samples taken.

3. Sampling Procedure

a) Samples shall be cut at locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing.

b) All holes in the geomembrane resulting from destructive sampling shall be immediately repaired in accordance with repair procedures specified in Section 624.05 (E).

4. <u>Size of Samples</u>. The samples shall be eleven (11) inches wide by twenty-four (24) inches long with the seam centered lengthwise. Two (2) 1-inch wide strips shall be cut from each end of the sample and these shall be tested (shear and peel) in the field by the installer. The remaining sample shall be cut into two (2) parts and distributed as follows:

a) One (1) portion for the Contractor, eleven (11) inches by eleven (11) inches.

b) One (1) portion to the Engineer or archive storage, eleven (11) inches by eleven (11) inches

5. <u>Field Testing</u>. The two (2), one (1) inch wide strips described in Section 623.06 (D)(4) shall be tested in the field by the installer and witnessed by the Engineer, by tensiometer, for peel and shear, respectively. Test strips shall meet the peel and shear values specified for trial seams in Section 624.05 (D)(2). If any field test sample fails to pass, then the procedures outlined in that Section shall be applied.

6. <u>Procedures for Destructive Test Failure</u>. The following procedures shall apply whenever a sample fails the destructive test, whether performed by field or laboratory testing:

a) The seam shall be reconstructed between any two (2) passed test locations, or

b) The seaming path can be traced to an intermediate location (at least ten (10) feet minimum from the location of the failed test in each direction) and a small sample taken for an additional field test at each location. If these additional samples pass the field tests, then full laboratory samples shall be taken. If these laboratory samples pass, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed.

7. Acceptance of Seams - All acceptable seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. In cases exceeding one hundred and fifty (150) feet of reconstructed seam, a sample taken from within the reconstruction zone must pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were seamed by the same personnel and/or apparatus or seamed during the same time shift.

E. Geomembrane Wrinkle. When seaming of a geomembrane liner is completed, or when seaming of a large area of a geomembrane liner is completed, and prior to placing overlying materials, the Engineer shall identify the location of excessive geomembrane wrinkles. Wrinkles so identified shall be cut, re-seamed and tested.

F. Seams That Cannot Be Non-Destructively Tested. The following procedures shall apply to locations where seams cannot be non-destructively tested:

1. All such seams shall be cap-stripped with the same geomembrane.

2. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.

G. Engineering Observation. If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations shall be observed by the Engineer and Contractor for uniformity and completeness.

H. Geomembrane Acceptance. The Contractor shall retain ownership and responsibility for the geomembrane until acceptance by the Owner. The geomembrane shall be accepted by the Owner when:

1. Conformance test results meet the requirements of the Contract Documents.

2. Required documentation including warranty from the manufacturer, fabricator and installer has been received and accepted.

3. The installation is complete and accepted by the Engineer.

4. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.

5. Written certification documents, including as-built drawings, have been received by the Engineer.

624.07 ANCHORAGE

Anchor liners using edge trenches as shown on the drawings.

SECTION 625 - GEOCOMPOSITE

Add the following new section:

625.01 DESCRIPTION

The work covered by these Specifications consists of furnishing and installing high density polyethylene (HDPE) geonet heat bonded and with one layer of 8 oz/yd^2 non-woven geotextile where shown on the Drawings or directed by the Engineer.

625.02 MATERIALS

A. Drainage Net

The drainage net shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide for planar flow. The drainage net shall be manufactured of polyethylene resin produced in the United States and compounded and manufactured specifically for the intended application. The natural polyethylene resin without the carbon black shall meet the following requirements:

Property	Test Method	Requirements
Density, g/cc	ASTM D 1505 or ASTM D 792	0.945 - 0.955
Melt Index, g/10 min.	ASTM D 1238 Condition E	< 1.0

Labels on each roll shall identify the thickness of the material, the width and length of the roll, lot and roll numbers, and name of the manufacturer. The drainage net rolls shall meet the requirements in this specification.

B. Geotextile

The geotextile shall be a non-woven, needle punched polyester or polypropylene fabric manufactured in the United States for the specific application. The geotextile rolls shall be 15 feet wide and shall meet the requirements in this specification.

C. Geocomposite

The geocomposite shall consist of the HDPE drainage net heat bonded and sandwiched between two layers of geotextile to create a double-sided geocomposite. The geocomposite shall be 13.5 feet wide. The geotextiles shall extend a minimum of 6 inches beyond the edges of drainage net on both sides of the geocomposite roll. The geotextile shall not be bonded to the drainage net within 6 inches from the edges of the rolls.

Materials shall have the minimum physical property characteristics, as outlined in Table 5 and Table 6. Certified test results showing that the sheeting meets or exceeds the Specification shall be submitted per Section 625.03 (E).

TABLE 5. GEONET SPECIFICATIONS

PROPERTY	TEST METHOD	MINIMUM REQUIREMENT
Thickness (mils nominal)	ASTM D-751	250.0
Compressive Strength (pounds/inch^2)	ASTM D 1621	100.0
Transmissivity @ 4000 psf (gal./min./ft.)	ASTM D 4716	0.5

TABLE 6. GEOTEXTILE SPECIFICATIONS

PROPERTY	TEST METHOD	MINIMUM REQUIREMENT
Unit Weight (oz/yd^2)	ASTM D-5261	8
Grab Strength (pounds)	ASTM D 4632	200
Permittivity (sec^{-1})	ASTM D 4491	1.3
UV Stability, % ret. (500 hr)	ASTM D 4355	70

625.03 INSTALLATION

A. Surface Preparation

1. Prior to deployment of the geocomposite, the Contractor shall inspect the underlying geomembrane surface to ascertain its suitability for installation in compliance with the terms of the product warranty and the requirements of this Specification.

2. Round edges of anchor trenches as recommended by the geocomposite manufacturer or cushion with geotextiles and backfill.

B. Geocomposite Installation

1. Only install enough panels that can be secured during that same day.

2. Do not damage geocomposite by handling, traffic, or leakage of hydrocarbons or any other means. Do not wear damaging shoes or engage in activities that could damage the geomembrane. Open or unroll geocomposite panels using methods that will not damage, stretch or crimp the geocomposite. Use methods that minimize wrinkles between adjacent panels. Place ballast on geocomposite to prevent uplift from wind. Use ballast that will not damage geocomposite. Repair damage to underlying materials prior to completing deployment of geocomposite. Do not allow vehicle traffic directly on geocomposite. Remove folded material. Visually inspect geocomposite for imperfections. Mark faulty or suspect areas for repair. Any portion

of the geocomposite damaged during installation shall be removed or repaired by using an additional piece of the same geocomposite as specified herein. The geocomposite shall be installed in a relaxed condition and shall be free of stress or tension upon completion of the installation. Stretching the geocomposite to fit is not permissible. Backfill anchor trenches.

C. Securing Geocomposite

1. Seam Layout shall meet the following requirements:

   a) Orient seams parallel to line of maximum slope, i.e., orient down, not across, slope.

2. The seaming procedure used shall be as follows:

   a) Field connections will be made to secure factory fabricated panels or rolls of geocomposite together in the field. Connections shall be formed by lapping the edges of panels a minimum of 2 inches. Any wrinkles shall be smoothed out.

   b) Secure overlapped edges of the geonet by plastic ties approximately every five (5) feet along the panel length. Use plastic ties that are white or a bright color for easy inspection. Do not use metallic ties.

   c) Extend connections to the outside edge of panels to be placed under the anchor berm and in the anchor trench.

   d) If securing operations are carried out at night, provide adequate illumination.

D. Defects and Repairs

1. Inspection

   a) During installation and securing, examine all areas of the geocomposite for defects, tears, undispersed raw materials and all sign of contamination by foreign matter. The surface of the geocomposite shall be clean at the time of the examination. Mark all areas suspected of deficiencies.

   b) Repair each suspect location.

2. Repair Procedures

   a) Repair all portions of the geocomposite exhibiting a flaw by removing the unsatisfactory material and replacing with new material that is overlapped and secured in place.

E. Geocomposite Acceptance. The Contractor shall retain ownership and responsibility for the geocomposite until acceptance by the Owner. The geocomposite shall be accepted by the Owner when:

1. Conformance test results meet the requirements of Table 6-1.

2. Required documentation including warranty from the manufacturer, fabricator and installer has been received and accepted.

3. The installation is complete and accepted by the Engineer.

4. Written certification documents, including as-built drawings, have been received by the Engineer.

5. Submittals shall be the same as those required for geomembrane in Section 623.

TABLE 6-1. CONFIRMATION SAMPLING FOR GEOCOMPOSITES

PARAMETER	TEST	MINIMUM TEST FREQUENCY	REJECTION CRITERIA
Crush Strength	ASTM D-1621	1 per lot[1]	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.
Thickness	ASTM D-5199	1 per lot[1]	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.
Transmissivity	ASTM D-4716 Width @ 14.5 psi Normal pressure & 0.1 ft/ft hydraulic	1 per lot[1]	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.

Notes:

(1) A lot is the smaller of 100,000 square feet or one production run.

SECTION 626 - GEOSYNTHETIC CLAY LINER (GCL)

Add the following new section:

626.01 DESCRIPTION

A. The work covered by these Specifications consists of furnishing and installing geosynthetic clay liner (GCL) where shown on the Drawings or directed by the Engineer.

B. **Definitions Used In This Section**

Geosynthetic Clay Liner (GCL). A manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetics. The GCL will be reinforced.

Minimum Average Roll Value. The minimum average value of a particular physical property of a material, for 95 percent of all of the material in the lot.

Overlap. Where two adjacent GCL panels contact, the distance measuring perpendicular from the overlying edge of one panel to the underlying edge of the other.

626.02 QUALITY ASSURANCE

1. Manufacture's Qualifications:
   The GCL manufacturer must have produced at least 10 million $ft^2$of GCL, with at least 8 million square feet installed.

2. Installer's Qualifications:
   The GCL installer must either have installed at least 1 million ft^2 of GCL, or must provide to the Engineer satisfactory evidence, through similar experience in the installation of other types of geosynthetics, that the GCL will be installed in a competent, professional manner.

3. Product Quality Documentation:
   The GCL manufacturer shall provide the Engineer with manufacturing QA/QC certification for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:
   a) Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the parameters swell index and fluid loss.
   b) Manufacturer's test data for finished GCL product(s) of bentonite mass/area, GCL tensile strength and GCL peel strength (if applicable) demonstrating compliance with the index parameters.
   c) GCL lot and roll numbers supplied for the project (with corresponding shipping information).
   d) Manufacturer's test data for finished GCL product(s) of GCL index flux, permeability and hydrated internal shear strength data demonstrating compliance with the performance parameters.

4. Delivery, Storage and Handling
   a) Deliver GCL to the site only after the Engineer receives and approves the required submittals. Damaged or unacceptable material shall be immediately removed from the site and replace at no cost to the owner.
   b) Prior to shipment, the GCL manufacturer shall label each roll, identifying:
      (1) Product identification information (Manufacturer's name and address, brand name, product code).
      (2) Lot number and roll number.
      (3) Roll length and weight.
   c) The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.
   d) All rolls shall be labeled and bagged in packaging that is resistant to photodegradation by ultraviolet (UV) rays.
   e) The manufacturer assumes responsibility for initial loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling and storage of the GCL are the responsibility of the Contractor, Installer or other designated party.
   f) A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.
   g) The party responsible for unloading the GCL should contact the manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.
   h) Storage of the GCL rolls shall be the responsibility of the installer. Ad dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry and well-drained.
   i) Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or by use of the dunnage shipped between rolls. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four).
   j) All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.
   k) The integrity and legibility of the labels shall be preserved during storage.

5. Warranty

   a) The installer of the GCL to be used in the work shall warrant his workmanship to be free of defects for two (2) years after final acceptance of the work. This warranty shall include, but not be limited to, all seams, anchor trenches, GCL attachments to appurtenances, and penetration seals. The GCL installer shall also obtain and furnish the Owner a warranty from the GCL manufacturer for the materials used. The material warranty shall be for defects or failure due to weathering for 10 years, with temperatures ranging from (-) minus 30 degrees Fahrenheit to (+) plus 110 degrees Fahrenheit, after the completion of the work on a prorata basis.

b) Should a defect or failure occur within the aforesaid periods, the GCL installer shall bear all costs for repair and/or replacement of the GCL and shall in addition bear all costs for the excavation of any cover backfill that is required to be removed in order to repair and/or replace the GCL. All materials removed to allow repairs to be made shall be reinstalled by the GCL installer in accordance with these special provisions.

626.03 SUBMITTALS

Two copies of the following documents shall be submitted by the Contractor at least three weeks prior to the shipment of the GCL to the site.

1. Conceptual description of the proposed plan for placement of the GCL panels over the area of installation.
2. GCL manufacturer's MQC Plan for documenting compliance of these specifications.
3. A representative sample of the GCLs.
4. A project reference list for the GCL(s) consisting of the principal details for at least ten projects totaling at least 10 million square feet in size.
5. Upon shipment, the Contractor shall furnish the GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications to verify that the materials supplied for the project are in accordance with Table 7-1.

626.04 MATERIALS

1. The GCL shall be a needle punched reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin staple fiber non-woven geotextile and shall comply with all of the criteria listed in this specification. The needle punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond.
2. Reinforced GCL shall be used on this project.
3. The minimum acceptable dimensions of full-size GCL panels shall be 150 feet in length and 13.8 feet in width. Short rolls (those manufactured to a length greater than 70 feet but less than a full-length roll) may be supplied at a rate no greater than 3 per truckload or 3 rolls every 36,000 square of GCL, whichever is less.
4. A 12 -inch overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.
5. The granular bentonite or bentonite sealing compound used for seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer.

TABLE 7-1. ACCEPTANCE TESTING FOR GCL

Parameter	Test Method	Frequency	Test Standard	Rejection Criteria
Mass per Unit Area	ASTM D-5993	1 per lot(1)	0.75 lb/ft^2 MIN	Materials must pass all acceptance testing before delivery to site
Hydraulic Conductivity	ASTM D-5887		5 x 10^{-9}cm/sec MAX	
Shear Strength	ASTM D-5321		500 psf MIN	
Peel Strength	ASTM D-4632		15 lbs MIN	

Notes:

(1) All material used on the project must be from the sampled lot.

626.05 GCL INSTALLATION

The Contractor shall install the geosynthetic clay liner (GCL) in accordance with the plans and with these special provisions. In the event of conflict, the more stringent procedure shall apply unless approved otherwise by the Engineer and EPA.

626.05.1 Subgrade Preparation

The subgrade to receive GCLs shall be prepared and compacted in accordance with the project specifications and plans, and shall be smooth, firm, and free of: vegetation, construction debris, sticks, sharp rocks, ice, abrupt changes in elevation, standing water, cracks larger than one-quarter inch in width, and any other foreign matter that could contact the GCL.

626.05.2 Placement

1. Needle punched GCL shall be placed on top of the Compacted Clay Liner and on the site wide cap as shown on the plans.

2. GCL rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) should be in accordance with the Engineer's or manufacturer's recommendations. Unless otherwise specified, however, the GCL shall be installed such that the product name printed on one side of the GCL faces up.

3. Subgrade slope transitions will be uniformly curved and smooth prior to placement of the GCL. Care shall be taken when placing GCL that the subgrade is free of sharp changes in slope and uneven or variable radius curved transitions which may lead to unacceptable wrinkles or poor contact with the subgrade.

4. Equipment which could damage the GCL shall not be allowed to travel directly on it. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.

5. Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering commonly known as a skip sheet or rub sheet may be used to reduce friction damage during placement.

6. The GCL shall be placed so that seams are parallel to the direction of the maximum slope. Seams should be located at least 3 feet from the toe and crest of slopes steeper than 4H:1V.

7. All GCL panels should lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels.

8. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, a geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it will be removed and replaced. The Engineers, CQA inspector, and GCL supplier should be consulted for specific guidance if premature hydration occurs.

626.05.3 Anchorage

As directed by the Plans, the end of the GCL roll shall be placed in an anchor trench at the top of the slope. The front edge of the trench should be rounded so as to eliminate any sharp corners. Loose soil should be removed from the floor of the trench. The GCL should cover the entire trench floor and the rear trench wall.

626.05.4 Seaming

1. The GCL seams are constructed by overlapping their adjacent edges. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Supplemental bentonite is required if the GCL has one or more non-woven needle-punched geotextiles.

2. The minimum dimension of the longitudinal overlap should be 12 inches. End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 24 inches.

3. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.

4. Bentonite-enhanced seams are constructed between the overlapping adjacent panels and described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6-inch line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap. The bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot.

626.05.5 Detail Work

1. The GCL shall be sealed around penetrations and embedded structures embedded in accordance with the design drawings and the GCL manufacturer.

2. Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid damage to the geotextile components of the GCL during the cutting process.

626.05.6 Damage Repair

If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 inches is achieved around all of the damaged area. Dry bentonite or bentonite mastic shall be applied around the damaged area at a rate of one-half pound per square foot prior to placement of the patch. The Contractor may wish to use an adhesive to affix the patch in place so that it is not displaced during cover placement.

626.05.7 Cover Placement

1. Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles (such as 4-wheel all-terrain vehicles) may be used to facilitate the installation of geosynthetic material placed over the GCL. The GCL supplier or CQA engineer should be contacted with specific recommendations on the appropriate procedures in this situation.

2. When a textured geomembrane is installed over the GCL, a temporary geosynthetic covering known as a slip sheet or rub sheet should be used to minimize friction during placement and to allow the textured geomembrane to be more easily moved into its final position.

3. Cyclical wetting and drying of GCL covered only with geomembrane can cause overlap separation. A soil cover should be placed promptly over the geomembrane covering the GCL, but not directly on the GCL. Geomembranes should be covered with a white geotextile and/or operations layer without delay to minimize the intensity of wet-dry cycling. If there is the potential for unconfined cyclic wetting and drying over an extended period of time, the longitudinal seam overlaps should be increased based on the project engineer's recommendations.

4. To avoid seam separation, the GCL should not be put in excessive tension by the weight or expansion of textured geomembrane on steep slopes. The project Engineer should be consulted about the potential for GCL tension to develop.

(THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK)

627.00 SOIL AMENDMENTS, SEEDBED PREPARATION, AND SEED MIX

Add the following new section.

627.01.1 Soil Amendments, Seedbed Preparation, And Seed Mix

A. Topsoiling. Topsoil shall cover all embankment, backfill, site grading and exposed cut slope areas in accordance with Standard Specification 610. Application rates shall be a minimum of 6 inches at all sites unless otherwise designated in the specifications or on the Drawings.

B. Seedbed Preparation. After the project site has been graded to final plan specifications the site to be seeded shall be cultivated to provide a uniform seedbed surface. The seedbed shall be cultivated sufficiently to reduce the soil to a state of good tilth when the soil particles on the surface are small enough to lie closely enough together to prevent the seed from being covered too deeply for optimum germination. Prior to executing the seeding, fertilizing, and mulching work items, the seedbed at all sites shall be prepared and conditioned so these items can most efficiently be completed in conformance with Standard Specification 610. The seeding, fertilizing, and mulching work items shall be executed only after the seedbed has been accepted by the Engineer.

C. Seeding and Fertilizing. All areas at the sites disturbed in the execution of the work shall be seeded and fertilized. These areas include that acreage disturbed under the designated work items.

Other areas which are disturbed by the Contractor's operation, will also require seeding and fertilizing. Any such disturbed areas will be considered as site damage and will not be measured or considered for payment. The cost of this work shall be absorbed solely by the Contractor.

All disturbed areas shall be seeded with the designated Grass Mix. Two mixes are provided. One mix is for use on land designated for return to agricultural use and the other applies to all other disturbed areas.

The Contractor shall accomplish this work in accordance with the Fertilizing and Seeding Subsection and the Mulching Subsection of Standard Specification 610, and also in accordance with the provisions contained herein.

1. Fertilizer. Fertilizer shall be applied at the rates specified below. Exceptions will be made for seed drills that are capable of incorporating the fertilizer and seed directly into the seedbed uniformly at the specified rates. Fertilizer shall be applied to the prepared seedbed prior to seeding or mulching and shall be blended with the topsoil as called for in Standard Specification 610, or concurrently with the seed (as "no till" drills allow).

   Fertilizer shall be applied to the prepared seedbed prior to seeding. The fertilizer shall be incorporated into the soil by discing, raking, or shallow plowing to the full depth of the topsoil or to a maximum depth of 6 inches, whichever is less. Fertilizer shall be incorporated with equipment operated at right angles to the slope of the land.

All areas, except areas that will be returned to agricultural production within one year of project completion, shall be fertilized with a balanced inorganic chemical fertilizer with the following nutrients:

Composition 26-10-5 150 lbs/acre

All required fertilizer certificates shall be provided to the Engineer a minimum of three days prior to fertilizing. The certification shall include the guaranteed analysis of the fertilizer(s) stated in terms of the percentages of nitrogen (N), available phosphorus (P205) and potash (K20) in that order. The fertilizer specification may be changed by the Owner to a fertilizer mix based on specific site soil samples at no cost to the Owner.

2. Seed Certification. Seed certifications as required by Standard Specification 610 shall be submitted to the Engineer prior to any seeding. The Contractor shall also submit a copy of the bill or other documentation from the seed supplier showing actual bulk weights of the individual seed types combined in the mix. The required certifications and documentation shall be provided to the Engineer at least three days prior to seeding.

3. Seeding. The following application rates for seed are based on the drill seeding method. The seed mixture shall be uniformly distributed over the areas shown on project plans. All planting shall be done between October 15 and May 20 of a given year, except as specified in writing by the Owner. Seed shall be drilled at a depth of 1/2 inch utilizing a pasture or rangeland type drill (including custom seeders, furrow drills, disc drills or no-till drills) with a roller/cultipacker integral to the seed drill equipment. Broadcast seeding method will not be utilized on this project. Hydraulic seeding will be allowed only on areas too steep for drill seeding. Where the hydraulic seeding method is used, the application rates listed below must be doubled at no additional cost to the Owner.

4. Tracking. Tracking will be required only on areas where mulch tilling cannot be accomplished.

DISTURBED AREAS DESIGNATED FOR RETURN TO AGRICULTURAL PRODUCTION

Common Name	Scientific Name	Variety	Seed Application Rate (PLS lbs/acre)[1]
Regreen	Triticum x Elytrigia	---	30
Total seeded species (PLS lbs/acre)[1]			30

[1] PLS (Pure Live Seed) seeding rate is based on drill seed application.
PLS seeding rate will be doubled for broadcast or hydroseeded applications.

DISTURBED AREAS NOT DESIGNATED FOR RETURN TO AGRICULTURAL PRODUCTION

Common Name	Scientific Name	Variety	Seed Application Rate (PLS lbs/acre)[1]
Streambank wheatgrass	Agropyron riparium	Sodar	2
Pubescent wheatgrass	Agropyron dasystachyum	Critana	2
Western wheatgrass	Agropyron smithii	Rosana	3
Bluebunch wheatgrass	Agropyron spicatum	Secar	3
Crested wheatgrass	Agropyron cristatum	Ephraim	2
Sideoats grama	Bouteloua curtipendula	Pierre	3
Regreen	Triticum x Elytrigia	---	10
Cicer milkvetch	Astragalus cicer	---	5
Total seeded species (PLS lbs/acre)[1]			30

[1] PLS (Pure Live Seed) seeding rate is based on drill seed application.
PLS seeding rate will be doubled for broadcast or hydroseeded applications.

D. Tackifier. Tackifier shall be applied with all hydromulched areas at the manufacturer's recommended rate of forty (40) pounds per acre for slopes flatter than 2:1 and eighty (80) pounds per acre for slopes 2:1 or steeper.

1. Summer Erosion Control Procedure. In the event the construction is completed after April 30 but before October 15, the disturbed areas shall then be either mulched immediately with a vegetative mulch of straw or hay, applied at a rate of 4,000 pounds per acre or a soil stabilizer applied at the manufacturer's recommendation with a hydroseeder. The mulch shall be anchored into the seedbed as specified in Standard Specification 610.

A "no-till" drill with "no-till" coulters may be used to seed and fertilize directly into the mulched areas requiring permanent seeding after the October 15 date. After October 15, fertilizer shall be applied to the work areas at the application rate noted and incorporated into the soil as specified in Standard Specification 610. Seed shall then be applied by drilling methods only.

END OF DOCUMENT

DIVISION 700 - MATERIALS

SECTION 716 – GEOTEXTILE

717.01 GENERAL

Use 6 oz. Nonwoven High Survivability geotextile.

END OF DOCUMENT

APPENDIX B

DRAWINGS

ASARCO LLC
EAST HELENA PLANT
CONCEPTUAL SITE WIDE COVER SYSTEM
JANUARY 2008

DRAWING LIST	
DWG. NO.	TITLE
GENERAL SHEETS	
1	DRAWING INDEX & VICINITY MAP
2	LEGEND AND ABBERVATION MAP
3	PLANT COVER SYSTEM - SITE PLAN
4	SITE WIDE PERMANENT COVER SYSTEM - GRADING PLAN
5	PROPOSED 2008 PERMANENT COVER SYSTEM - GRADING PLAN
6	DETAILS
7	
?????	
8	XX
9	XX
10	
11	
12	
13	
14	
?????	
15	
16	
17	
18	
19	
20	
21	
22	
23	
?????	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	

REVISIONS NO	BY	DATE	DESCRIPTION	REVISIONS NO	BY	DATE	DESCRIPTION

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 7054		
DRAWN BY	SDP	1/17/07
CHECKED BY	MWR	1/23/07
APPROVED BY	MJO	1/24/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CONCEPTUAL SITE WIDE COVER SYSTEM
DRAWING INDEX & VICINITY MAP

DRAWING FILE NUMBER
705402H001.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER: 1
REV

UPDATE TIME: 8:17AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H001.dwg

GENERAL SYMBOLS

SYMBOLS REPRESENT NEW OR EXISTING STRUCTURES, LINES AND WORK. NEW WORK IS DISTINGUISHED FROM EXISTING WITH A SOLID VERSUS SCREENED LINE.

NEW (SOLID)

EXISTING (SCREENED)

EXISTING TO BE DEMOLISHED

ARROW INDICATES DIRECTION OF PLAN NORTH

NORTH

SCALE
(In Feet)

20 0 20 40 60

ARROW OR FLAG INDICATES DIRECTION OF VIEW OF SECTION PLANE

A

INDICATES SHEET WHERE SECTION IS SHOWN. "–" INDICATES SECTION IS SHOWN ON SAME SHEET.

SECTION MARKER

SECTION A KEYWAY
1/2"=1'

INDICATES SHEET WHERE SECTION IS SHOWN. "–" INDICATES SECTION IS SHOWN ON SAME SHEET.

SECTION OR DETAIL CALLOUT

X CONSTRUCTION NOTE

X SIGN NOTE

SPECIFIC NOTE CALLOUT

SITE SYMBOLS

SYMBOL IN PLAN	DESCRIPTION
UV	UTILITY VAULT (TEL., ELEC.)
PP	POWER POLE
TEL	TELEPHONE POLE
CP-X	HORIZONTAL CONTROL POINT
75.5	SPOT ELEVATION
81.5	FINISHED GRADE ELEVATION
0+00	CONSTRUCTION STATIONING
1.5%	SLOPE PITCH
PI NO. 13	POINT OF INTERSECTION
CO	CLEAN OUT
MH	SANITARY SEWER OR STORM SEWER MANHOLE
	STORM DRAIN CATCH BASIN
	CONCRETE REACTION BLOCKING
	FIRE HYDRANT
	LIGHT POLE W/ LUMINAIRE
BM	SURVEY MONUMENT OR BENCHMARK
	TRAFFIC CONTROL SIGN
	TRAFFIC CONTROL BARRICADE
	EXISTING PUMP
	PROPOSED PUMP
	EMBANKMENT SLOPE (SLOPE DARTS INDICATE DOWNSLOPE)
—x—x—	WIRE FENCE OR FIELD FENCE
	CHAINLINK FENCE
	WOODEN FENCE
	BREAKLINE
	EXISTING INTERMEDIATE GROUND SURFACE CONTOUR
450	EXISTING INDEX GROUND SURFACE CONTOUR
	PROPOSED INTERMEDIATE GROUND SURFACE CONTOUR
450	PROPOSED INDEX GROUND SURFACE CONTOUR
	DRAINAGE FLOW
	DRAINAGE DITCH
	PERENNIAL/GENERALIZED STREAM
	EPHEMERAL STREAM
	PROPERTY LINE
	RIGHT OF WAY LINE
	CENTERLINE
—PH—PH—PH—	TELEPHONE LINE
—P—P—P—	POWER LINE
—G—G—G—	GAS PIPELINE
—SS—SS—SS—	SANITARY SEWER
—SD—SD—SD—	STORM DRAIN
—TV—TV—TV—	TV CABLE LINE
—W—W—W—	WATER LINE
	EXISTING GROUND SURFACE (IN SECTION)
	PROPOSED GROUND SURFACE (IN SECTION)
	GEONET LINER
	PROPERTY BOUNDARY
	SITE CAP BOUNDARY

MATERIALS IN SECTION AND PLAN

NOTE: BOXES WITHOUT HATCH PATTERNS ARE NOT APPLICABLE

PLAN VIEW EXISTING/PROPOSED	SECTION VIEW EXISTING/PROPOSED	DESCRIPTION
		DEMOLITION
		PRECAST CONCRETE
		CAST-IN-PLACE CONCRETE
		MORTAR, GROUT OR PLASTER
NOT APPLICABLE		METAL PLATE OR CASTING
		ASPHALT/CONCRETE PAVING
		NATURAL GROUND SOIL OR EARTH
		COMPACTED FILL OR BACKFILL
NOT APPLICABLE		BEDROCK
		RIPRAP, LOOSE GRAVEL OR ROCK
		CRUSHED ROCK OR GRAVEL
NOT APPLICABLE		TOPSOIL OR RECLAMATION COVER
NOT APPLICABLE		COMPACTED CLAY OR BENTONITE

STANDARD MATERIAL LAYERS

SURFACE LAYERS

- TOP SOIL
- CONCRETE
- ASPHALT CONCRETE
- FILL LAYER (BORROW SOIL)
- SOIL (CLASSIFIED)
- BUILDINGS
- SOIL

PROTECTIVE LAYERS

- FILL LAYER (BORROW SOIL)
- SOIL (CLASSIFIED)

SEPARATION LAYERS

- GEOTEXTILE LAYER (WOVEN)
- GEOTEXTILE LAYER (NON-WOVEN)
- SAND
- SOIL (CLASSIFIED)

DRAINAGE LAYERS

- GRAVEL
- SAND
- SYNTHETIC DRAIN (SECTION)
- SYNTHETIC DRAIN (PLAN)

BARRIER LAYERS

- COMPACTED CLAY LINER
- GEOSYNTHETIC CLAY LINER
- FLEXIBLE MEMBRANE LINER
- PETROTAC LINER

SOURCE LAYERS

- WASTE SOIL GENERIC

UNDERLAYING LAYERS

- SLAG
- NATIVE SOILS

GENERAL ABBREVIATIONS

A	A	AIR, AERATOR
	AB	ANCHOR BOLT
	ABN	ABANDON IN PLACE
	ABND	ABANDONED
	ABS	ACRYLONITRILE BUTADIENE STYRENE
	AC	AIR COMPRESSOR, AIR CONDITIONER(ING)
	ACI	AMERICAN CONCRETE INSTITUTE
	ACP	ASPHALTIC CONCRETE
	ADDN	ADDITION, ADDITIONAL
	ADS	ADVANCED DRAINAGE SYSTEMS (TM)
	AFF	ABOVE FINISH FLOOR
	AFM	AIR FLOW METER
	AGG	AGGREGATE
	AMP	AMPERE
	ATB	ASPHALT TREATED BASE
	AHU	AIR HANDLING UNIT
	ALT	ALTERNATE
	ALUM	ALUMINUM
	APPROX	APPROXIMATE
	AR	AIR RELEASE
	ASSY	ASSEMBLY
	AVG	AVERAGE
B	BCV	BALL CHECK VALVE
	BF	BLIND FLANGE
	BFV	BUTTERFLY VALVE
	BGS	BELOW GROUND SURFACE
	BITUM	BITUMINOUS
	BLDG	BUILDING
	BM	BENCHMARK, BEAM
	BOG	BOTTOM OF GRILL
	BOP	BOTTOM OF PIPE
	BOT	BOTTOM
	BP	BACKFLOW PREVENTOR
	BRK	BRICK
	BTW	BETWEEN
	BSP	BLACK STEEL PIPE
	BST	BITUMINOUS SURFACE TREATMENT
	BU	BELL UP
	BV	BALL VALVE
C	C	CURB
	C&G	CURB & GUTTER
	CB	CATCH BASIN
	CCL	COMPACTED CLAY LINER
	CDF	CONTROL DENSITY FILL
	CF	CUBIC FEET
	CFM	CUBIC FEET PER MINUTE
	CFS	CUBIC FEET PER SECOND
	CI	CAST IRON
	CIP	CAST IRON PIPE
	CJ	CONSTRUCTION JOINT
	CL	CENTERLINE
	CLG	CEILING
	CLR	CLEAR, CLEARANCE
	CMP	CORRUGATED METAL PIPE
	CMU	CONCRETE MASONRY UNIT
	CO	CLEAN OUT
	COL	COLUMN
	CONN	CONNECTION
	CONC	CONCRETE
	CONST	CONSTRUCTION
	CONT	CONTINUOUS, CONTINUATION
	CP	CONCRETE PIPE
	CPLG	COUPLING
	CSP	CAST IRON SOIL PIPE
	CS	CHLORINE SOLUTION
	CTR	CENTER
	CU	COPPER
	CW	COLD WATER
	CV	CHECK VALVE
	CY	CUBIC YARD
D	D	DOOR
	DEG	DEGREE
	DET	DETAIL
	DIA	DIAMETER
	DIM	DIMENSION
	DIFF	DIFFUSER
	DI	DUCTILE IRON
	DISCH	DISCHARGE
	DIST	DISTANCE
	DL	DEAD LOAD
	DMJ	DOUBLE MECHANICAL JOINT
	DN	DOWN
	DP	DRAIN PUMP
	DR	DRAIN
	DS	DUCT SUPPORT
	DV	DIAPHRAGM VALVE
	DWG	DRAWING
E	E	ELECTRICAL CONDUIT, EAST
	EA	EACH
	ECC	ECCENTRIC
	EE	EACH END
	EF	EXHAUST FAN, EACH FACE
	EFFL	EFFLUENT
	EJ	EXPANSION JOINT
	EJM	EXPANSION JOINT MATERIAL
	EL	ELEVATION
	ELB	ELBOW
	ELEC	ELECTRICAL
	EMH	ELECTRICAL MANHOLE
	ENGR	ENGINEER
	EQUIP	EQUIPMENT
	EQ	EQUAL
	EUH	ELECTRIC UNIT HEATER
	EWH	ELECTRIC WATER HEATER
	EXIST	EXISTING
	EXP	EXPANSION
	EXT	EXTERIOR, EXTERNAL
F	FAB	FABRICATION
	FB	FLOOR BEAM
	FC	FLUSHING CONNECTION, FAN COIL
	FDN	FOUNDATION
	FE	FIRE EXTINGUISHER, FLOW ELEMENT
F	FILT	FILTER
	FILTF	FILTER FABRIC
	FIN	FINISHED
	FLG	FLANGE
	FLR	FLOOR
	FM	FORCE MAIN, FLOW METER
	FML	FLEXIBLE MEMBRANE LINER
	FOB	FINE ORE BIN BUILDING
	FOT	FLAT ON TOP
	FPT	FEMALE PIPE THREAD
	FRP	FIBERGLASS REINFORCED PLASTIC
	FSL	FLOW SWITCH
	FT	FEET, FOOT, FLOW TRANSMITTER
	FTG	FOOTING
G	G	GAS
	GA	GAGE
	GAL	GALLON
	GALV	GALVANIZED
	GALVS	GALVANIZED STEEL
	GCL	GEOSYNTHETIC CLAY LINER
	GEONET	GEOTEXTILE
	GEOTX	GEOTEXTILE
	GPM	GALLONS PER MINUTE
	GND	GROUND
	GRTG	GRATING
	GRV	GRAVITY ROOF VENTILATOR
	GS	GRATING SUPPORT
	GSP	GALVANIZED STEEL PIPE
	GV	GATE VALVE
	GWB	GYPSUM WALLBOARD
H	H	HATCH, HIGH
	HB	HOSE BIBB
	HDPE	HIGH DENSITY POLYETHYLENE
	HC	HEATING COIL
	HH	HEX HEAD
	HK	HOOK
	HM	HOLLOW METAL
	HMC	HARNESSED MECHANICAL COUPLING
	HORIZ	HORIZONTAL
	HP	HIGH POINT
	HR	HANDRAIL
	HS	HEADED STUD
	HT	HEIGHT
	HV	HOSE VALVE
	HVAC	HEATING, VENTILATION & AIR CONDITIONING
	HW	HOT WATER
	HWL	HIGH WATER LEVEL
I	I	INFLUENT
	ID	INSIDE DIAMETER
	IE	INVERT ELEVATION
	IN	INCH
	INCAN	INCANDESCENT
	INSTR	INSTRUMENT(TATION)
	INV	INVERT
	IRR	IRRIGATION
J	JAN	JANITOR
	JB	JUNCTION BOX
	JT	JOINT
K	KGV	KNIFE GATE VALVE
L	L	LEFT
	LB	POUND
	LDPE	LOW DENSITY POLYETHYLENE
	LL	LIVE LOAD
	LAB	LABORATORY
	LAV	LAVATORY
	LE	LEVEL ELEMENT
	LF	LINEAR FOOT
	LS	LEVEL SWITCH
	LT	LEVEL TRANSMITTER
	LWL	LOW WATER LEVEL
M	MAINT	MAINTENANCE
	MATL	MATERIAL
	MAX	MAXIMUM
	MB	MACHINE BOLT
	MC	MECHANICAL COUPLING
	MCC	MOTOR CONTROL CENTER
	MDMJ	MODIFIED DOUBLE MECHANICAL JOINT
	MECH	MECHANICAL
	MED	MEDIUM
	MFR	MANUFACTURER
	MH	MANHOLE
	MISC	MISCELLANEOUS
	MIN	MINIMUM
	MO	MASONRY OPENING
	MOD	MODIFIED, MODIFICATION
	MRGWB	MOISTURE RESISTANT GYPSUM WALLBOARD
	MSE	MECHANICALLY STABILIZED EARTH
	MTL	METAL
N	N	NORTH
	NG	NATURAL GAS
	NIC	NOT IN CONTRACT
	NO	NUMBER
	NPT	NATIONAL PIPE THREADS
	NRS	NONRISING STEM
	NTS	NOT TO SCALE
O	OA	OUTSIDE AIR
	OC	ON CENTER(S)
	OCF	ON-SITE CONTAINMENT FACILITY
	OD	OUTSIDE DIAMETER
	OF	OVERFLOW
	OH	OVERHEAD, OPPOSITE HAND
	OPNG	OPENING
	OPP	OPPOSITE
	ORIG	ORIGINAL
	ORD	OVERFLOW ROOF DRAIN
	OS & Y	OUTSIDE STEM AND YOKE
	OZ	OUNCES
P	PC	PIPE COLUMN
	PCV	PRESSURE CONTROL VALVE
	PE	PLAIN END, PRESSURE ELEMENT, PRIMARY EFFLUENT
	PERF	PERFORATED
	PF	PROPELLER FAN
	PG	PRESSURE GAGE
	PI	POINT OF INTERSECTION, PRIMARY INFLUENT
	PL	PLATE, PLACE, PLASTIC
	P/L	PROPERTY LINE
	PP	POWER PANEL
	PRI	PRIMARY
	PROJ	PROJECTION
	PRV	PRESSURE REDUCING VALVE
	PS	PIPE SUPPORT
	PSF	POUNDS PER SQUARE FOOT
	PSI	POUNDS PER SQUARE INCH
	PSL	PIPE SLEEVE
	PT	PRESSURE TRANSMITTER
	PV	PLUG VALVE
	PVC	POLYVINYL CHLORIDE (PIPE)
	PVMT	PAVEMENT
	PW	POTABLE WATER
R	R	RADIUS, RIGHT
	RB	ROOF BEAM
	RCP	REINFORCED CONCRETE PIPE
	RD	ROOF DRAIN, ROLLUP DOOR
	RDL	ROOF DRAIN LEADER
	RECIRC	RECIRCULATION
	RECT	RECTANGULAR
	RED	REDUCER
	REF	REFERENCE
	REINF	REINFORCE(ING)
	REQD	REQUIRE(ED)
	RM	ROOM(S)
	R/W	RIGHT OF WAY
	R&R	REMOVE AND REPLACE PER ORIGINAL
	R&S	REMOVE AND SALVAGE TO OWNER
	RV	ROOF VENTILATOR
S	S	SOUTH
	SA	SOURCE AREA
	SAM	SAMPLE
	SCH	SCHEDULE
	SD	STORM DRAIN
	SEC	SECTION
	SF	SUPPLY FAN
	SHT	SHEET
	SIM	SIMILAR
	SL	SLOPE
	SPEC	SPECIFICATION
	SQ	SQUARE
	SRF	SEDIMENT REMOVAL FACILITY
	SS	SANITARY SEWER, STAINLESS STEEL
	STA	STATION
	STD	STANDARD
	STIR	STIRRUP
	STL	STEEL
	SV	SOLENOID VALVE
	SWMM	CITY OF TACOMA/PIERCE COUNTY STORM WATER MANAGEMENT MANUAL
	SY	SQUARE YARD
T	T	TREADS
	TBM	TEMPORARY BENCHMARK
	TC	TOP OF CURB
	TCV	TEMPERATURE CONTROL VALVE
	TE	TOP ELEVATION
	TEL	TELEPHONE
	TEMP	TEMPORARY
	TH	TEST HOLE
	THD	THREADED
	THK	THICK
	TOC	TOP OF CASING
	TOD	TOP OF DECK
	TOF	TOP OF FOOTING
	TOS	TOP OF SUPPORT
	TOW	TOP OF WALL
	TS	TUBULAR STEEL
	TT	TEMPERATURE TRANSMITTER
	TYP	TYPICAL
	T&B	TOP AND BOTTOM
U	UH	UNIT HEATER
	UK	UNKNOWN
V	V	VALVE
	VAC	VACUUM
	VAR	VARNISH
	VD	VOLUME DAMPER
	VERT	VERTICAL
	VIF	VERIFY IN FIELD
	VTR	VENT THRU ROOF
W	W	WATER, WINDOW, WIDE, WEST
	WC	WATER CLOSET
	WD	WOOD
	WH	WATER HEATER
	WP	WATERPROOF(ED),(ING)
	WS	WATERSTOP
	WSP	WELDED STEEL PIPE
	WT	WEIGHT
	WWF	WELDED WIRE FABRIC
	W/	WITH
	W/O	WITHOUT
X	XFMR	TRANSFORMER

REVISIONS	NO	BY	DATE	DESCRIPTION

REVISIONS	NO	BY	DATE	

SCALE VERIFICATION
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 7054	
DRAWN BY	JSD
CHECKED BY	
APPROVED BY	
SCALE: AS NOTED	

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CONCEPTUAL SITE WIDE COVER SYSTEM PLAN
GENERAL LEGEND
AND ABBREVIATIONS

DRAWING FILE NUMBER
705402H003.dwg
AUTOCAD 2007 DRAWING (DWG)
SHEET NUMBER 2
REV

UPDATE TIME: 12:09AM
LT \HEL\020708\t\Land Projects\705402\dwg\705402H003.dwg

LEGEND

- PROPOSED LOCATION OF CONTAMINATED SOIL REMOVAL TO ACHIEVE EPA'S PREFERRED CLEANUP ALTERNATIVES.
- PROPOSED SITEWIDE MULTILAYERED COVER SYSTEM
- PROPOSED SLAG PILE EVAPOTRANSPIRATION COVER SYSTEM
- LOWER LAKE SEP IMPROVEMENTS
- 4:1 SLOPE — SLOPE DART - SHOWS DIRECTION OF RUNOFF AND SLOPE ANGLE
- SECURITY FENCE

NOTES:

THE COVER SYSTEM WILL INCLUDE NINE (9) PRIMARY ELEMENTS. THESE INCLUDE:

- GRADE THE SITE TO PROMOTE DRAINAGE.
- REMOVE CONTAMINATED SOILS ON THE WEST BOUNDARY PORTION OF THE PLANT AND INCORPORATE UNDER A PLANT WIDE COVER SYSTEM.
- COVER THE SLAG PILE
- COVER THE REMAINING PORTIONS OF THE SITE WHERE SOIL REMOVAL WILL NOT BE CONDUCTED BECAUSE COMPLETE REMOVAL IS NOT FEASIBLE OR PRACTICAL.
- MODIFY EXISTING STORM WATER STRUCTURES TO CONVEY WATER OFF SITE
- ARMOR PRICKLY PEAR CREEK
- IMPLEMENT THE SUPPLEMENTAL ENVIRONMENTAL PROJECT (SEP) FOR LOWER LAKE
- REMOVE THE EAST BRIDGE AND ASSOCIATED FLOODPLAIN ENCROACHMENTS AND
- SECURE THE SITE

REVISIONS	NO	BY	DATE	DESCRIPTION

REVISIONS	NO	BY	DATE	

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 7054		
DRAWN BY	JSD	
CHECKED BY		
APPROVED BY		
SCALE: AS NOTED		

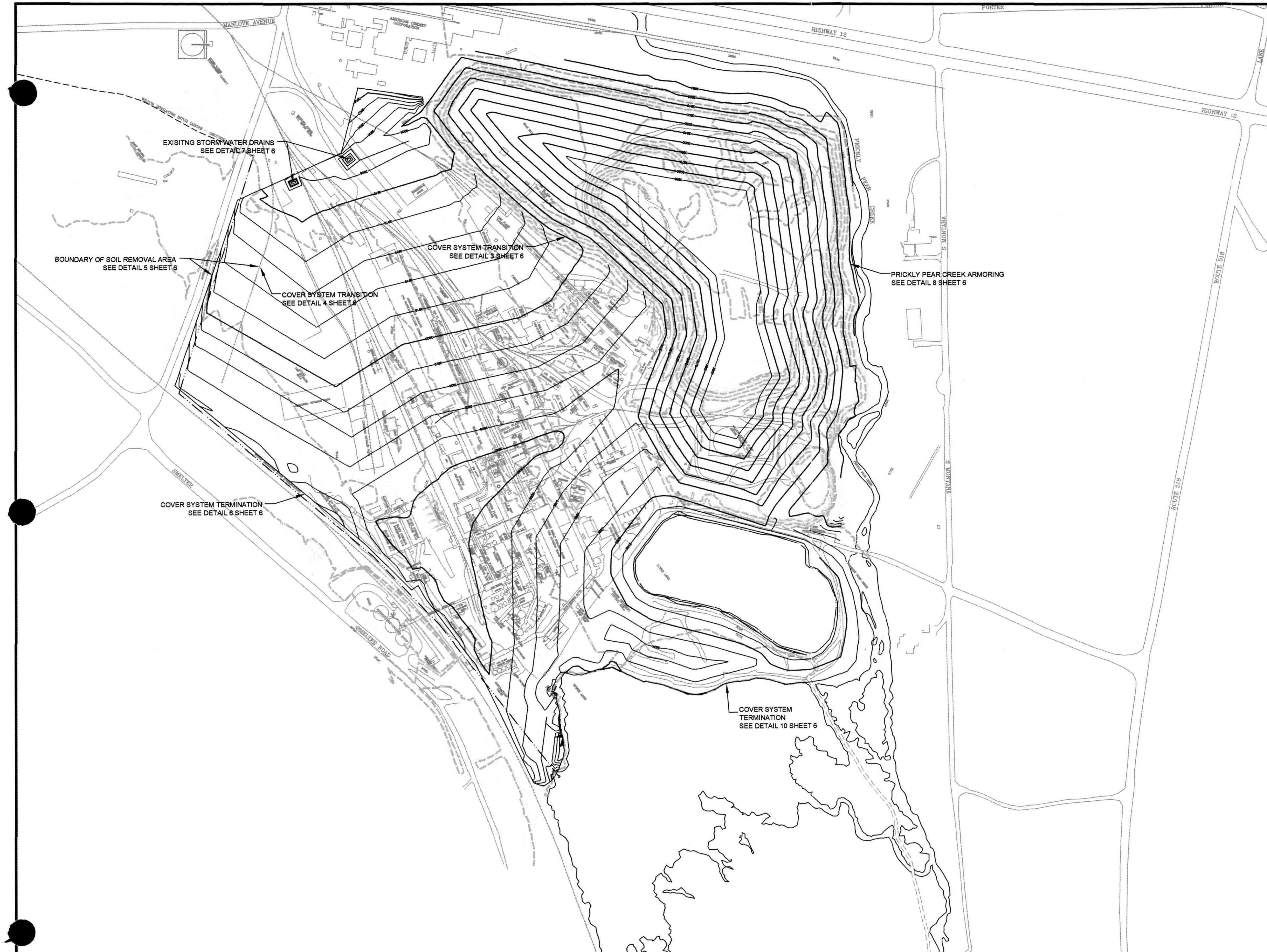
Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CONCEPTUAL SITE WIDE COVER SYSTEM PLAN

PLANT COVER SYSTEM
SITE PLAN

DRAWING FILE NUMBER	
705402H002.dwg AUTOCAD 2007 DRAWING (DWG)	
SHEET NUMBER	REV
3	△

UPDATE TIME: 10:27AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H002.dwg



SCALE
(In Feet)

200 0 200 400 600

(Approximate Only)

LEGEND

3900 EXISTING CONTOURS
3900 PROPOSED CONTOURS

REVISIONS NO	BY	DATE	DESCRIPTION	REVISIONS NO	BY	DATE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.:	7054	
DRAWN BY	SDP	1/17/07
CHECKED BY	MWR	1/23/07
APPROVED BY	MJO	1/24/07
SCALE:	AS NOTED	

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

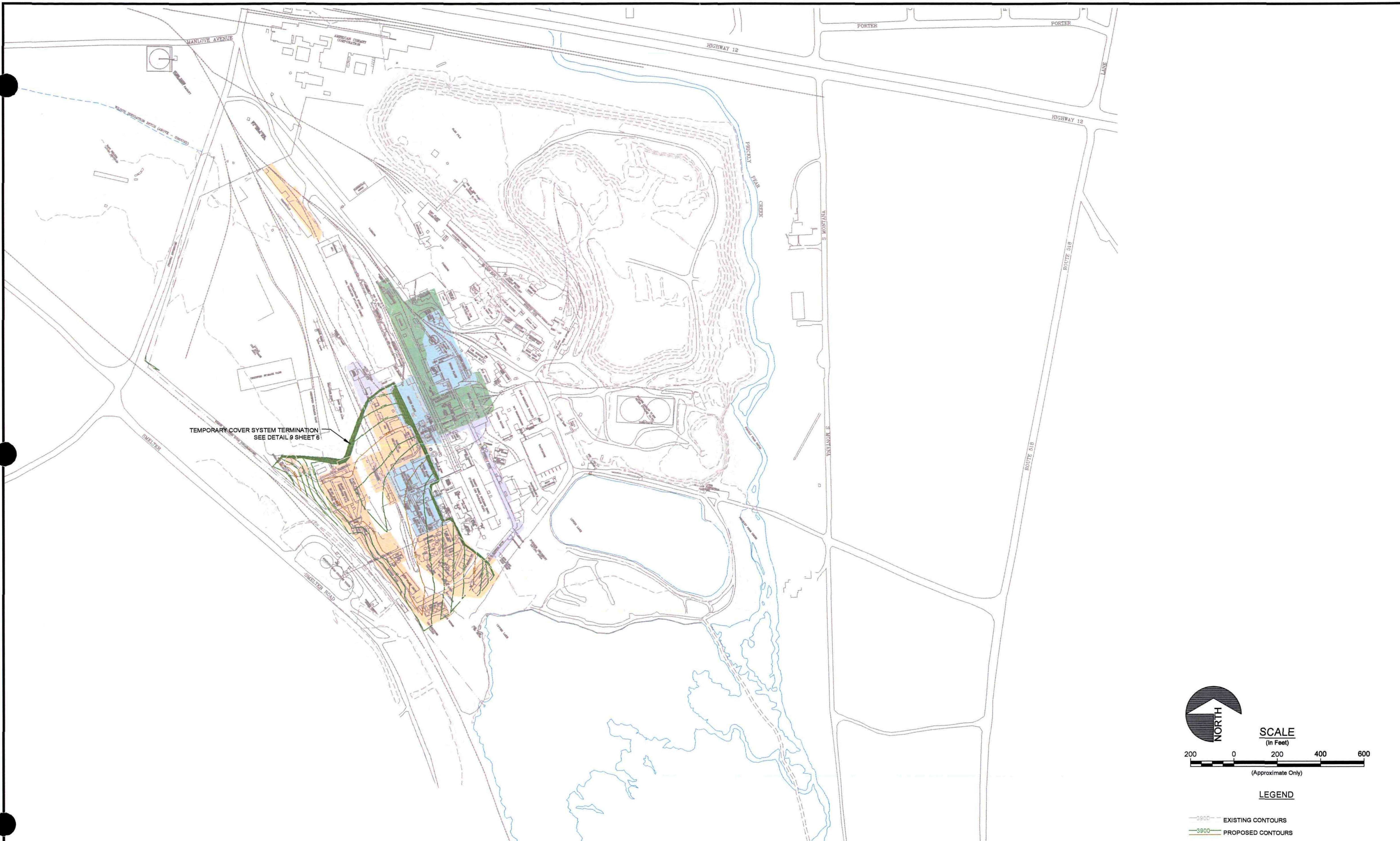
ASARCO LLC - EAST HELENA PLANT
CONCEPTUAL SITE WIDE COVER SYSTEM PLAN

SITE WIDE PERMANENT COVER SYSTEM
GRADING PLAN

DRAWING FILE NUMBER
705402H004.dwg
AUTOCAD 2004 DRAWING (DWG)

SHEET NUMBER: 4
REV

UPDATE TIME: 10:57AM
LT \HEL\020708\I:\Land Projects\705402\dwg\705402H004.dwg



REVISIONS	NO	BY	DATE	DESCRIPTION	REVISIONS	NO	BY	DATE	

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

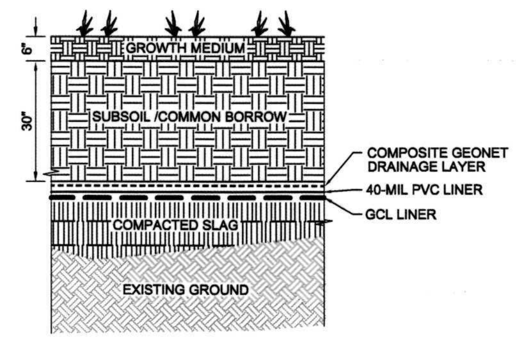
Project No.: 7054		
DRAWN BY	SDP	1/17/07
CHECKED BY	MWR	1/23/07
APPROVED BY	MJO	1/24/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

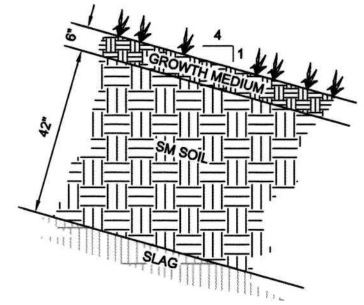
ASARCO LLC - EAST HELENA PLANT
CONCEPTUAL COVER SYSTEM PLAN
PROPOSED 2008 PERMANENT COVER SYSTEM
GRADING PLAN

DRAWING FILE NUMBER
705402H006.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER 5
REV

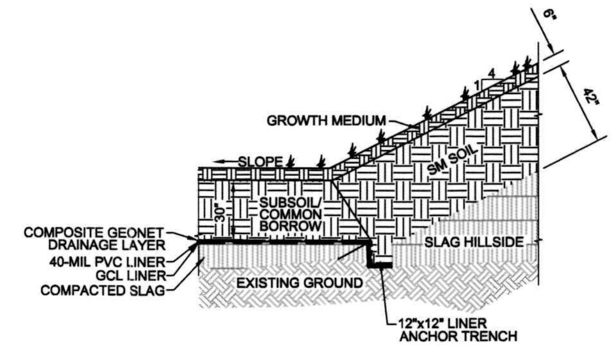
UPDATE TIME: 7:46AM
JSD\HEL\010908\I:\Land Projects\705402\dwg\705402H006.dwg



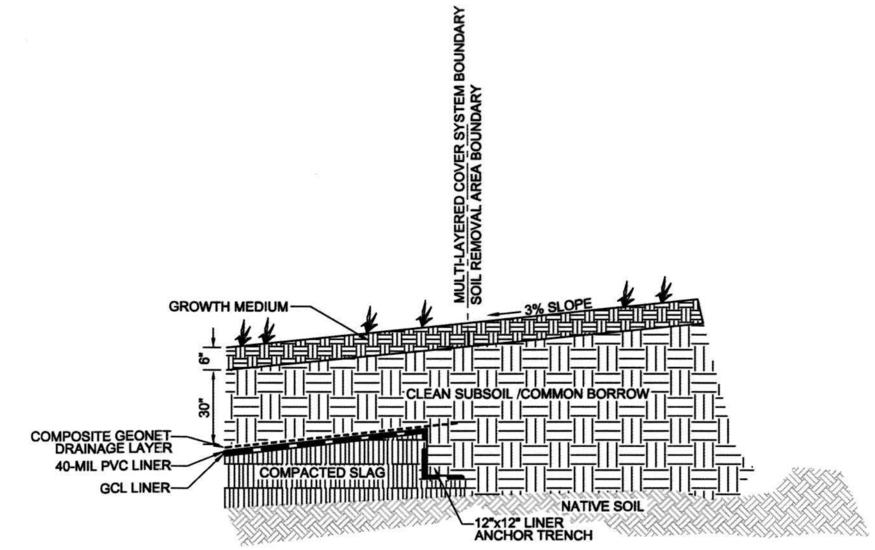
1/6 DETAIL
MULTI-LAYER COVER SYSTEM (TYP)



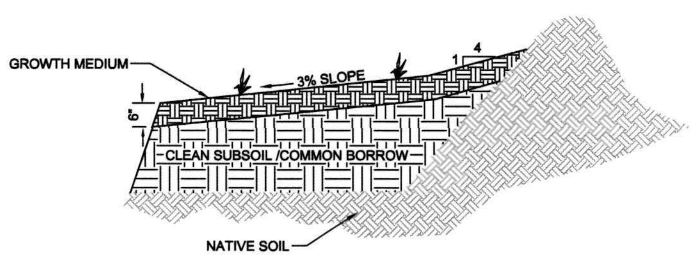
2/6 DETAIL
SLAG PILE COVER SYSTEM (TYP)



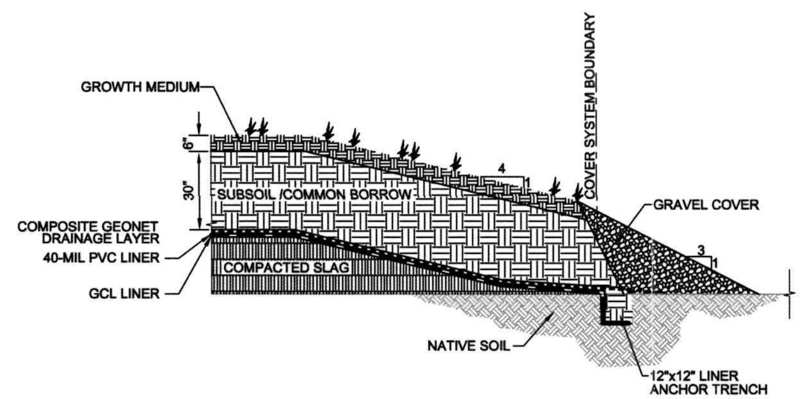
3/6 DETAIL
COVER SYSTEM TRANSITION AT TOE OF SLAG PILE (TYP)



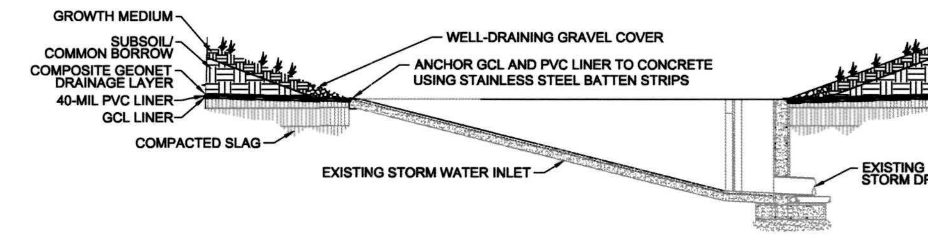
4/6 DETAIL
COVER SYSTEM TRANSITION AT TOE OF SLAG PILE



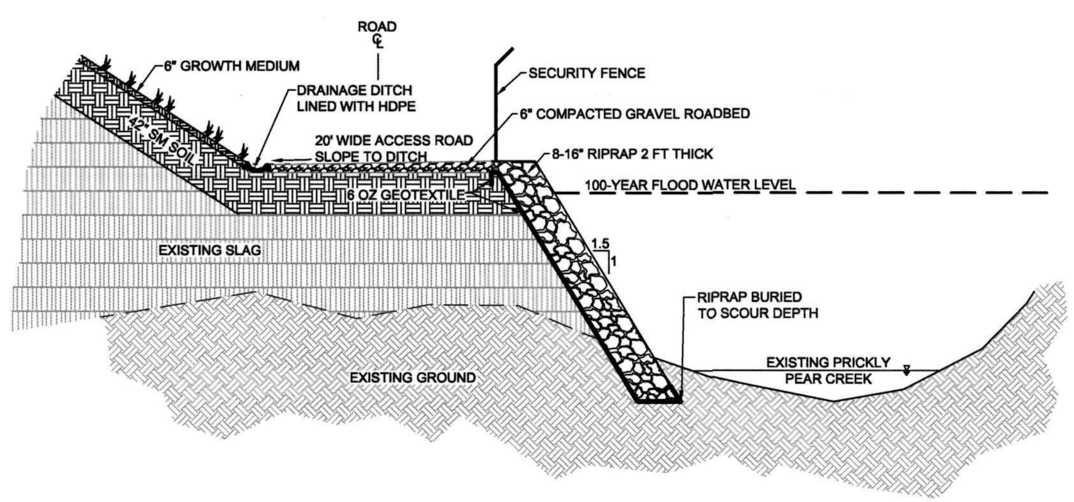
5/6 DETAIL
BOUNDARY OF SOIL REMOVAL AREA (TYP)



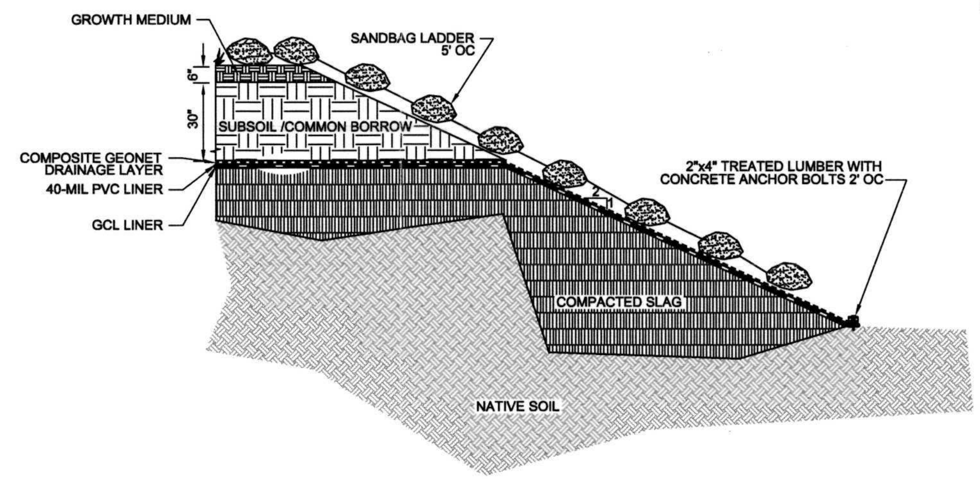
6/6 DETAIL
COVER SYSTEM TERMINATION AT PROPERTY BOUNDARY (TYP)



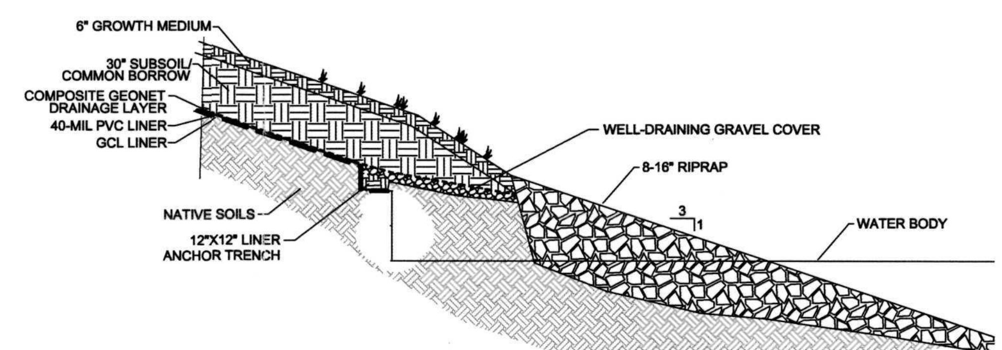
7/6 DETAIL
SURFACE DRAIN/SEDIMENT TRAP (TYP)



8/6 DETAIL
PRICKLY PEAR CREEK RIPRAP (TYP)



9/6 DETAIL
TEMPOARAY COVER SYSTEM TERMINATION (TYP)



10/6 DETAIL
COVER SYSTEM TERMINATION AT UPPER AND LOWER LAKE

NO	BY	DATE	DESCRIPTION	NO	BY	DATE	DESCRIPTION

REVISIONS

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 7054		
DRAWN BY	SDP	1/17/07
CHECKED BY	MWR	1/23/07
APPROVED BY	MJO	1/24/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CONCEPTUAL SITE WIDE COVER SYSTEM PLAN

DETAILS

DRAWING FILE NUMBER
705402H008.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER 6
REV

UPDATE TIME: 11:28AM
SDP\HEL\020708\I:\Land Projects\705402\dwg\705402H008.dwg

APPENDIX C

HELP OUTPUT FILES

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.01   (14 OCTOBER 1994)               **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                  **
**                     USAE WATERWAYS EXPERIMENT STATION                    **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP\EHPR.D4
TEMPERATURE DATA FILE:        C:\HELP\EHTEMP.D7
SOLAR RADIATION DATA FILE:    C:\HELP\EHSR.D13
EVAPOTRANSPIRATION DATA:      C:\HELP\EHEVT.D11
SOIL AND DESIGN DATA FILE:    C:\HELP\EHCAP4.D10
OUTPUT DATA FILE:             C:\HELP\EHCAP4.OUT
```

Geonet @ 1% Slope
drainage = Ø.84
percolation = Ø
avg. head = Ø

```
TIME:  14:41     DATE:  12/ 4/2007


******************************************************************************

     TITLE:  East Helena Cap

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                       LAYER  1
                                       --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER    7
           THICKNESS                     =       6.00   INCHES
           POROSITY                      =       0.4730 VOL/VOL
           FIELD CAPACITY                =       0.2220 VOL/VOL
           WILTING POINT                 =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT    =       0.1272 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =   0.520000001000E-03 CM/SEC


                                       LAYER  2
```

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9

THICKNESS	=	30.00	INCHES
POROSITY	=	0.5010	VOL/VOL
FIELD CAPACITY	=	0.2840	VOL/VOL
WILTING POINT	=	0.1350	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2736	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.190000006000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.25	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	74.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.310	INCHES

UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.840	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.894	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.974	INCHES
TOTAL INITIAL WATER	=	8.974	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
HELENA MONTANA

MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	138
END OF GROWING SEASON (JULIAN DATE)	=	266
AVERAGE ANNUAL WIND SPEED	=	7.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	54.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	63.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HELENA MONTANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.66	0.44	0.69	1.01	1.72	2.01
1.04	1.18	0.83	0.65	0.54	0.60

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HAVRE MONTANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
11.00	19.60	28.40	42.70	54.50	62.80
69.60	67.80	56.80	45.90	29.70	18.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HELENA MONTANA

STATION LATITUDE = 46.36 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.70	0.38	0.70	0.98	1.78	1.96
	1.04	1.10	0.91	0.64	0.52	0.57
STD. DEVIATIONS	0.39	0.27	0.40	0.51	0.74	0.89
	0.55	0.58	0.50	0.38	0.28	0.32
RUNOFF						
TOTALS	0.013	0.062	0.056	0.054	0.027	0.000
	0.000	0.000	0.000	0.000	0.002	0.001
STD. DEVIATIONS	0.069	0.149	0.147	0.097	0.102	0.002
	0.000	0.000	0.000	0.000	0.008	0.007
EVAPOTRANSPIRATION						
TOTALS	0.461	0.474	0.628	0.731	1.586	1.849
	1.119	0.892	0.932	0.601	0.517	0.449
STD. DEVIATIONS	0.131	0.186	0.283	0.462	0.782	0.808
	0.649	0.550	0.529	0.302	0.202	0.139
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0002	0.0050	0.1085	0.3117
	0.1905	0.0483	0.0685	0.0715	0.0266	0.0115
STD. DEVIATIONS	0.0000	0.0000	0.0012	0.0145	0.1462	0.2197
	0.1825	0.0767	0.1371	0.1192	0.0594	0.0443
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 4						
AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0006	0.0018
	0.0011	0.0003	0.0004	0.0004	0.0002	0.0001
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0008	0.0013

0.0010	0.0004	0.0008	0.0007	0.0003	0.0003

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	11.30	(1.541)	41003.8	100.00
RUNOFF	0.215	(0.2507)	778.71	1.899
EVAPOTRANSPIRATION	10.239	(1.2827)	37167.66	90.645
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.84221	(0.41408)	3057.218	7.45595
PERCOLATION/LEAKAGE THROUGH FROM LAYER 4	0.00000	(0.00000)	0.003	0.00001
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.000	(0.5884)	0.15	0.000

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	1.62	5880.600
RUNOFF	0.815	2956.8899
DRAINAGE COLLECTED FROM LAYER 3	0.08809	319.75760
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ACROSS LAYER 4	0.016	
SNOW WATER	1.90	6889.9492

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3911
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0714

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	0.7618	0.1270
2	8.2110	0.2737
3	0.0025	0.0100
4	0.0000	0.0000
SNOW WATER	0.000	

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE              **
**              HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************
```

Geonet @ 3% slope
drainage = 0.85"
percolation = 0
Avg. head = 0

```
PRECIPITATION DATA FILE:      C:\HELP\EHPR.D4
TEMPERATURE DATA FILE:        C:\HELP\EHTEMP.D7
SOLAR RADIATION DATA FILE:    C:\HELP\EHSR.D13
EVAPOTRANSPIRATION DATA:      C:\HELP\EHEVT.D11
SOIL AND DESIGN DATA FILE:    C:\HELP\EHCAP2.D10
OUTPUT DATA FILE:             C:\HELP\EHCAP2.OUT

TIME:  14:29     DATE:  12/ 4/2007

******************************************************************************

     TITLE:  East Helena Cap

******************************************************************************

     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.

                                LAYER  1
                                --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
          THICKNESS                   =       6.00    INCHES
          POROSITY                    =       0.4730 VOL/VOL
          FIELD CAPACITY              =       0.2220 VOL/VOL
          WILTING POINT               =       0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT  =       0.1270 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.520000001000E-03 CM/SEC


                                LAYER  2
```

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9

THICKNESS	=	30.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2840 VOL/VOL
WILTING POINT	=	0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2737 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.190000006000E-03 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25 INCHES
POROSITY	=	0.8500 VOL/VOL
FIELD CAPACITY	=	0.0100 VOL/VOL
WILTING POINT	=	0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0453 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000 CM/SEC
SLOPE	=	3.00 PERCENT
DRAINAGE LENGTH	=	100.0 FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.25 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	0.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	74.00
FRACTION OF AREA ALLOWING RUNOFF	=	100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000 ACRES
EVAPORATIVE ZONE DEPTH	=	8.0 INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.309 INCHES

UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.840	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.894	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.984	INCHES
TOTAL INITIAL WATER	=	8.984	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
HELENA MONTANA

MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	138
END OF GROWING SEASON (JULIAN DATE)	=	266
AVERAGE ANNUAL WIND SPEED	=	7.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	54.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	63.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HELENA MONTANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.66	0.44	0.69	1.01	1.72	2.01
1.04	1.18	0.83	0.65	0.54	0.60

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HAVRE MONTANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
11.00	19.60	28.40	42.70	54.50	62.80
69.60	67.80	56.80	45.90	29.70	18.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HELENA MONTANA

STATION LATITUDE = 46.36 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.70	0.38	0.70	0.98	1.78	1.96
	1.04	1.10	0.91	0.64	0.52	0.57
STD. DEVIATIONS	0.39	0.27	0.40	0.51	0.74	0.89
	0.55	0.58	0.50	0.38	0.28	0.32
RUNOFF						
TOTALS	0.013	0.061	0.056	0.056	0.027	0.000
	0.000	0.000	0.000	0.000	0.002	0.001
STD. DEVIATIONS	0.069	0.148	0.147	0.101	0.101	0.003
	0.000	0.000	0.000	0.000	0.008	0.007
EVAPOTRANSPIRATION						
TOTALS	0.462	0.470	0.654	0.724	1.617	1.820
	1.111	0.911	0.902	0.606	0.507	0.448
STD. DEVIATIONS	0.132	0.187	0.285	0.455	0.799	0.758
	0.646	0.599	0.493	0.330	0.201	0.137
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0002	0.0000	0.0002	0.0036	0.1043	0.3069
	0.1904	0.0482	0.0771	0.0747	0.0310	0.0111
STD. DEVIATIONS	0.0012	0.0000	0.0012	0.0110	0.1368	0.2247
	0.1750	0.0778	0.1372	0.1077	0.0736	0.0477
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 4						
AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0002	0.0006
	0.0004	0.0001	0.0002	0.0001	0.0001	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0003	0.0004

0.0003 0.0001 0.0003 0.0002 0.0001 0.0001

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	11.30	(1.541)	41003.8	100.00
RUNOFF	0.218	(0.2537)	789.95	1.927
EVAPOTRANSPIRATION	10.231	(1.2481)	37137.50	90.571
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.84770	(0.39241)	3077.149	7.50455
PERCOLATION/LEAKAGE THROUGH FROM LAYER 4	0.00000	(0.00000)	0.002	0.00001
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.000	(0.5174)	-0.85	-0.002

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	1.62	5880.600
RUNOFF	0.814	2954.6626
DRAINAGE COLLECTED FROM LAYER 3	0.09050	328.51944
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00002
AVERAGE HEAD ACROSS LAYER 4	0.005	
SNOW WATER	1.90	6889.9492
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3889	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0679	

****

****

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	0.7629	0.1272
2	8.2067	0.2736
3	0.0025	0.0100
4	0.0000	0.0000
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.01   (14 OCTOBER 1994)              **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP\EHPR.D4
TEMPERATURE DATA FILE:        C:\HELP\EHTEMP.D7
SOLAR RADIATION DATA FILE:    C:\HELP\EHSR.D13
EVAPOTRANSPIRATION DATA:      C:\HELP\EHEVT.D11
SOIL AND DESIGN DATA FILE:    C:\HELP\EHCAP1.D10
OUTPUT DATA FILE:             C:\HELP\EHCAP1.OUT
```

12" sand @ 3%
drainage = 0.86"
percolation = 0
avg. head = 0.179

```
TIME:  14:23      DATE:  12/ 4/2007


******************************************************************************

     TITLE:  East Helena Cap

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =       6.00   INCHES
           POROSITY                   =       0.4730 VOL/VOL
           FIELD CAPACITY             =       0.2220 VOL/VOL
           WILTING POINT              =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.1270 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =   0.520000001000E-03 CM/SEC


                                  LAYER  2
```

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 9

THICKNESS	=	30.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2840 VOL/VOL
WILTING POINT	=	0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2737 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.190000006000E-03 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0453 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02 CM/SEC
SLOPE	=	3.00 PERCENT
DRAINAGE LENGTH	=	100.0 FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.25 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	0.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	74.00
FRACTION OF AREA ALLOWING RUNOFF	=	100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000 ACRES
EVAPORATIVE ZONE DEPTH	=	8.0 INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.309 INCHES

UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.840	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.894	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.517	INCHES
TOTAL INITIAL WATER	=	9.517	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
HELENA MONTANA

MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	138
END OF GROWING SEASON (JULIAN DATE)	=	266
AVERAGE ANNUAL WIND SPEED	=	7.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	54.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	63.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HELENA MONTANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.66	0.44	0.69	1.01	1.72	2.01
1.04	1.18	0.83	0.65	0.54	0.60

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HAVRE MONTANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
11.00	19.60	28.40	42.70	54.50	62.80
69.60	67.80	56.80	45.90	29.70	18.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HELENA MONTANA

STATION LATITUDE = 46.36 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.70	0.38	0.70	0.98	1.78	1.96
	1.04	1.10	0.91	0.64	0.52	0.57
STD. DEVIATIONS	0.39	0.27	0.40	0.51	0.74	0.89
	0.55	0.58	0.50	0.38	0.28	0.32
RUNOFF						
TOTALS	0.013	0.062	0.056	0.057	0.026	0.000
	0.000	0.000	0.000	0.000	0.002	0.001
STD. DEVIATIONS	0.069	0.149	0.147	0.100	0.099	0.001
	0.000	0.000	0.000	0.000	0.009	0.007
EVAPOTRANSPIRATION						
TOTALS	0.461	0.471	0.663	0.735	1.615	1.838
	1.104	0.890	0.906	0.595	0.495	0.441
STD. DEVIATIONS	0.131	0.187	0.298	0.461	0.784	0.789
	0.661	0.570	0.494	0.319	0.195	0.140
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0092	0.0021	0.0006	0.0017	0.0411	0.1618
	0.2212	0.1556	0.0860	0.0882	0.0632	0.0315
STD. DEVIATIONS	0.0171	0.0039	0.0011	0.0051	0.0577	0.1005
	0.1085	0.0974	0.0677	0.0872	0.0729	0.0462
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 4						
AVERAGES	0.0175	0.0044	0.0012	0.0034	0.0900	0.4426
	0.6031	0.3806	0.1922	0.2096	0.1417	0.0618
STD. DEVIATIONS	0.0325	0.0083	0.0022	0.0100	0.1538	0.3440

0.4257 0.3487 0.1864 0.2580 0.1817 0.0944

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	11.30	(1.541)	41003.8	100.00
RUNOFF	0.218	(0.2528)	789.58	1.926
EVAPOTRANSPIRATION	10.216	(1.2768)	37083.77	90.440
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.86237	(0.38127)	3130.400	7.63442
PERCOLATION/LEAKAGE THROUGH FROM LAYER 4	0.00000	(0.00000)	0.012	0.00003
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.179	(0.103)		
CHANGE IN WATER STORAGE	0.000	(0.5622)	-0.01	0.000

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 50

	(INCHES)	(CU. FT.)
PRECIPITATION	1.62	5880.600
RUNOFF	0.815	2956.8765
DRAINAGE COLLECTED FROM LAYER 3	0.02351	85.33944
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00028
AVERAGE HEAD ACROSS LAYER 4	2.867	
SNOW WATER	1.90	6889.9492
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3642	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0730	

****

****

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	0.7623	0.1271
2	8.2102	0.2737
3	0.5434	0.0453
4	0.0000	0.0000
SNOW WATER	0.000	

****
****

APPENDIX D

EVAPOTRANSPIRATION COVER SYSTEM CALCULATIONS

Estimate of Soil Storage Capacity in ET Cap

Assumptions: All precipitation is either infiltrated or removed via evapotranspiration with no loss in volume associated with runoff

Step 1: Calculate amount of excess water left in soil column after potential evapotranspiration losses

Scenario 1:

Use Average Normal Monthly Precipitation and Average Monthly Evapotranspiration for Water Years 1997-2007

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
PRECIP	0.6	0.46	0.71	0.97	1.91	2.12	1.11	1	1.11	0.72	0.59	0.59
ET	0.62	1.12	2.66	4.10	6.06	6.80	8.84	6.92	4.34	2.40	0.98	0.57
NET MOISTURE STORED	-0.02	-0.66	-1.95	-3.13	-4.15	-4.68	-7.73	-5.92	-3.23	-1.68	-0.39	0.02

negative numbers represent more water being lost due to evapotranspiration than fell as precipitation

Required Soil Storage -S_{req} *0.02 inches* using average monthly precipitation and potential evaporation values

Scenario 2:

Use Wettest Year on Record (1975) Precipitation and Smallest Monthly Potential Evapotranspiration For Water Years 1997-2007

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
PRECIP	1.26	0.72	0.88	3	1.95	2.83	3.89	2.47	0.47	2.68	0.48	0.31
ET	0.32	0.82	1.85	3.51	5.39	5.05	7.35	6.12	3.98	2.09	0.68	0.37
NET MOISTURE STORED	0.94	-0.10	-0.97	-0.51	-3.44	-2.22	-3.46	-3.65	-3.51	0.59	-0.20	-0.06

Required Soil Storage -S_{req} *1.54 inches* using wettest year on record (1975) ◄----- **use this one**

Step 2: Calculate required thickness of soil layer to store the calculated required soil storage volume

Soil properties taken from NRCS Soil Survey Data

Typical Soil Sappington-Amesha Silt/Clay Loams
Typical Available Water Content 0.12 in/in from NRCS Soil Survey

$$L \geq (S_{req}+FS)/(\text{Available Water Content})^1$$

where:

L = Minimum Coversoil Thickness in inches
Sreq = Required Soil Storage Volume in inches
Available Water Content = taken from NRCS Soil survey for Sappington-Amesha Silt/Clay Loams in inches/inches
FS (Factor of Safety)= 2 inches General rule[1]
L≥ 29.5 inches Using wettest year on record (1975)

Minimum Coversoil Thickness **29.5 inches** ***< Proposed Coversoil Thickness of 48 inches***

[1]Preliminary Design Methods, Benson, C.H., University of Wisconsin-Madison 2006

K:/project/7054/ET cap Design calculations.xls

APPENDIX E

RIPRAP DESIGN CALCULATIONS

Determine Minimum Stone Weight

Variables:
- W = theoretical minimum rock mass (size or weight) which resists forces of flowing water and remains stable on slope of stream or river bank (lbs)
- V = velocity to which bank is exposed (fps)
  - for parallel flow multiply average channel velocity by 0.67
  - for impinging flow multiply average channel velocity by 1.33
- SG = specific gravity of the rock
- r = 70 degrees (for randomly placed rubble, a constant) (=1.22173 radians)
- a = outside slope face angle with horizontal (degrees) use maximum 33.69 degrees (1V:1.5H)

$$W = \frac{0.00002 * V^6 * SG}{(SG-1)^3 * \sin^3(r-a)}$$

Average Channel Velocity for 100 year flood = 8 fps (from HEC modeling)
SG = 2.65
a = 33.69 degrees (0.588001 radians)

Parallel Flow (v = 5.36)

W=	(0.00002*(8*0.67)^6*2.65)/((2.65-1)^3*(SIN(1.22173-0.588))^3) = 1.35 lb
RSP-Class	Backing # 3 From Table 5-1 of CalTrans Bank and Shore Rock Protection Manual

Impinging Flow (v = 10.64)

W (lbs) =	(0.00002*(8*1.33)^6*2.65)/((2.65-1)^3*(SIN(1.22173-0.588))^3) = 82.45 lb
RSP-Class	Backing #1B From Table 5-1 of CalTrans Bank and Shore Rock Protection Manual

Determine the Required Layers of RSP

From Section 5-1-E and Table 5.2 of CalTrans Bank and Shore Rock Protection Manual

1. No inner layers are required
2. RSP-Fabric Type is A
3. Riprap can be placed directly on RSP-fabrics.

Determine the Thickness of the RSP Revetment

From Section 5-1-F of CalTrans Bank and Shore Rock Protection Manual

Volume (ft^3) = weight/[(62.4 lbs/ft^3)*SG]
D_{50} =([Volume/((4/3)*Pi())]$^{1/3}$)*2

D_{50} Parallel	=(((1.35/(62.4*2.65))/((4/3)*PI()))^(1/3))*2	=0.250 ft
D_{50} Impinging	=(((82.45/(62.4*2.65))/((4/3)*PI()))^(1/3))*2	=0.984 ft

From Table 5-3 of CalTrans Bank and Shore Rock Protection Manual

Method B, dumped RSP can be used

Parallel	Backing # 3	Minimum Thickness	0.75 ft
Impinging	Backing # 1	Minimum Thickness	1.8 ft

Determine Size Distribution for Riprap

From Table 3-1 of Hydraulic Design of Flood Control Channels, US Army Corps of Engineers

For W_{50} of 82.45 lbs and Specific Weight of 165 pcf:
D_{100}(max) = 18"

		Diameter (ft)	Diameter (in)
W_{100} (lbs)			
292	=((292*6)/(PI()*165))^(1/3)	1.50	18.0
117	=((117*6)/(PI()*165))^(1/3)	1.11	13.3
W_{50} (lbs)			
86	=((86*6)/(PI()*165))^(1/3)	1.00	12.0
58	=((58*6)/(PI()*165))^(1/3)	0.88	10.5
W_{15} (lbs)			
43	=((43*6)/(PI()*165))^(1/3)	0.79	9.5
18	=((18*6)/(PI()*165))^(1/3)	0.59	7.1

Using size designations for Backing #1 from CalTrans Bank and Shore Rock Protection Manual

		Diameter (ft)	Diameter (in)
W_{100} (lbs)			
200	=((200*6)/(PI()*165))^(1/3)	1.32	16
W_{50} (lbs)			
75	=((75*6)/(PI()*165))^(1/3)	0.95	11
W_{10} (lbs)			
25	=((25*6)/(PI()*165))^(1/3)	0.66	8

The following will be used for Riprap Specifications:

Sieve Designation	Percent Passing
16-inch	95-100
12-inch	40-60
8-inch	0-10

Determine Quanity of Riprap Needed

2836 cubic yards — From Civil 3D volume calculations; Assumes slope of 33.69 degrees

Assume 3000 cy to allow for more gentle slopes in some areas

References

California Bank and Shore Rock Slope Protection Design. State of California Department of Transportation, October 2000.

Hydraulic Design of Flood Control Channels. American Society of Civil Engineers, Adapted from U.S. Corps of Engineers Technical Engineering and Design Guide, Engineer Manual EM 1110-2-1601. 1995.

APPENDIX F

FLOODPLAIN ANALYSIS

FLOOD ANALYSIS FOR PRICKLY PEAR CREEK

EAST HELENA SMELTER

EAST HELENA AND LEWIS AND CLARK COUNTY, MONTANA

Prepared for:

ASARCO LLC
P.O. Box 1230
East Helena, MT 59635

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

November 2007

TABLE OF CONTENTS

LIST OF TABLES ii
LIST OF FIGURES..iii
LIST OF APPENDICES iii
1.0 INTRODUCTION..1-1
1.1 HYDROLOGIC INVESTIGATION...1-3
1.2 HYDRAULIC ANALYSIS...1-4
1.2.1 Establishing Base Floodplain Conditions 1-4
1.3 IMPACTS TO FLOODPLAIN ELEVATIONS AND BOUNDARIES WITH A PROPOSED BERM 1-7
1.3.1 Impacts to Floodplain Elevations and Boundaries with Entire Removal of the East Entrance Smelter Dam.................................1-11
1.3.2 Impacts to Floodplain Elevations and Boundaries with Partial Removal of the East Entrance Smelter Dam.................................1-14
1.3.3 Issues Related to Construction of a Flood-Protection Berm...........1-14
1.3.4 Issues Related to Removal of the Entire Smelter Dam..................1-16
1.3.5 Issues Related to Partial Removal of the Smelter Dam 1-17
2.0 SUMMARY..2-1
3.0 REFERENCES 3-1

LIST OF TABLES

TABLE 1-1. HEC-RAS MODEL RESULTS WITH IMPORTED HEC-2 DATA FROM LEWIS & CLARK COUNTY AND EAST HELENA FISs – 100 YEAR DISCHARGE (2,190 cfs)...1-5
TABLE 1-2. SUMMARY OF HEC-RAS MODEL RESULTS WITH UPDATED AND CROSS SECTIONS – 100 YEAR DISCHARGE (2,190 CFS) PRICKLY PEAR CREEK AT ASARCO PLANT 1-6

TABLE 1-3. SUMMARY OF HEC-RAS MODEL RESULTS WITH ADDITION OF BERM – 100 YEAR DISCHARGE (2,190 cfs) PRICKLY PEAR CREEK AT ASARCO PLANT 1-10

TABLE 1-4. SUMMARY OF HEC-RAS MODEL RESULTS WITH ENTIRE DAM REMOVED – 100 YEAR DISCHARGE (2,190 cfs) PRICKLY PEAR CREEK AT ASARCO PLANT 1-12

TABLE 1-5. SUMMARY OF HEC-RAS MODEL RESULTS WITH PARTIAL DAM REMOVED – 100 YEAR DISCHARGE (2,190 cfs) PRICKLY PEAR CREEK AT ASARCO PLANT 1-15

LIST OF FIGURES

FIGURE 1-1. PRICKLY PEAR CREEK CURRENT 100-YEAR FLOODPLAIN BOUNDARIES AND FLOODWAY 1-2

FIGURE 1-2. PRICKLY PEAR CREEK UPDATED FLOODPLAIN BOUNDARIES WITH INSERTED CROSS SECTIONS 1-8

FIGURE 1-3. PROPOSED BERM AROUND LOWER LAKE 1-9

FIGURE 1-4. PRICKLY PEAR CREEK FLOODPLAIN MODIFICATIONS WITH ENTIRE DIVERSION DAM REMOVED 1-13

LIST OF APPENDICES

APPENDIX A CONCEPTUAL WORK DESCRIPTION FOR PARTIAL REMOVAL OF SMELTER DAM

FLOOD ANALYSIS FOR PRICKLY PEAR CREEK
EAST HELENA SMELTER

EAST HELENA AND LEWIS AND CLARK COUNTY, MONTANA

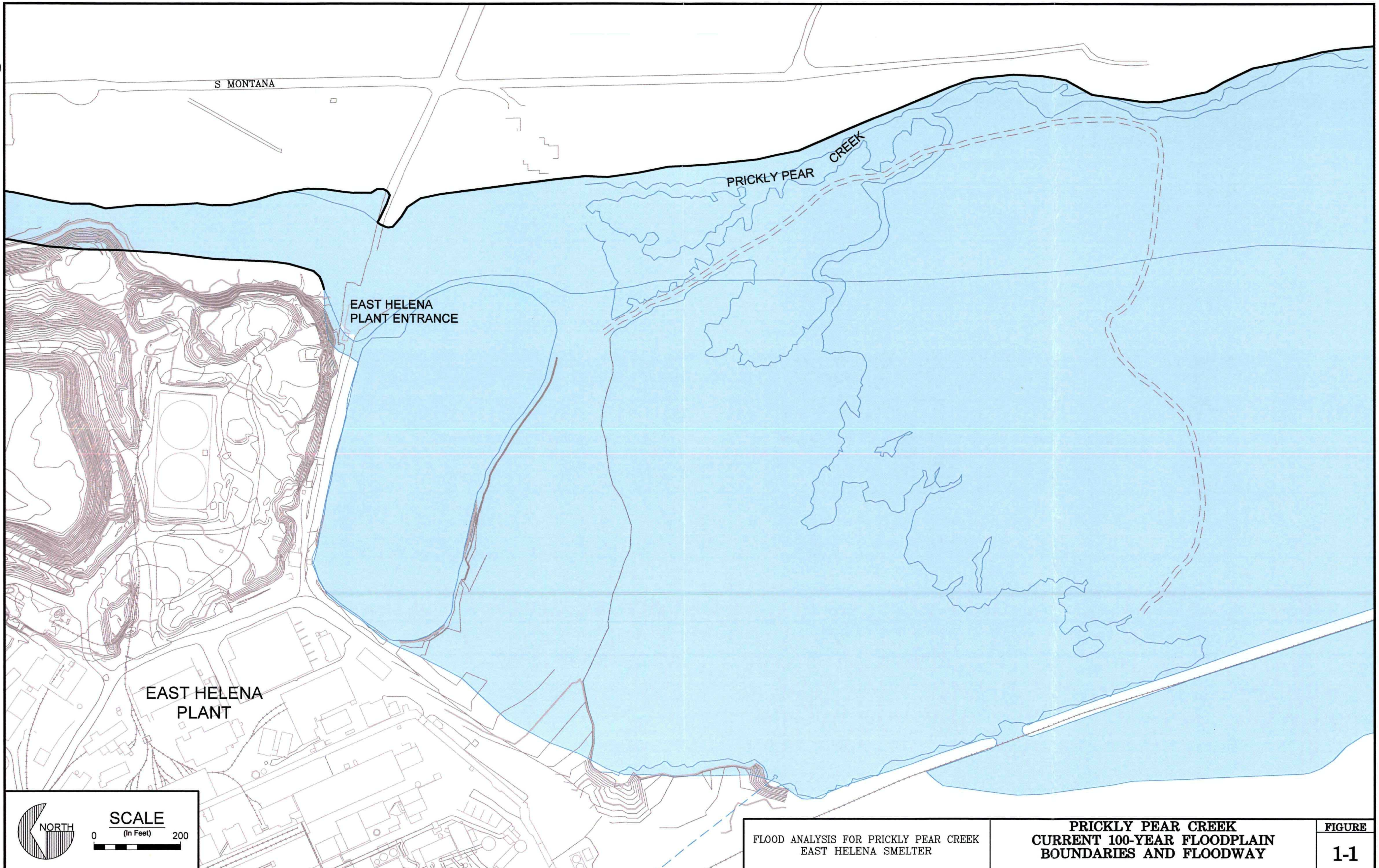
1.0 INTRODUCTION

As part of the overall evaluation of requirements for closure of the ASARCO East Helena Plant facility, Hydrometrics conducted a flood analysis of Prickly Pear Creek. The purpose of this analysis was to evaluate options for mitigating flood impacts. Prickly Pear Creek flows generally in a southerly direction along the east side of the smelter property. Existing floodplain boundaries for the 100-year flood for Prickly Pear Creek, which is defined as a flood having a one percent probability of exceedance in any given year, are published in the Flood Insurance Rate Maps (FIRMs) for the Flood Insurance Studies (FISs) for the City of East Helena (FEMA, 1985) and Lewis and Clark County (FEMA, 2002). The floodplain studies were conducted by contractors for the Federal Emergency Management Agency (FEMA) as part of a comprehensive floodplain management program for the State of Montana. The current floodplain boundaries in the area of ASARCO's East Helena Plant, shown as blue shading on Figure 1-1, encompass all of Upper and Lower Lake.

The objectives of this analysis include:

1. Characterize the current impacts to the East Helena Plant from a 100-year flood on Prickly Pear Creek, using updated topographic data in the area of Lower Lake.

2. Evaluate the feasibility of constructing a dike or placing fill to prevent Prickly Pear Creek from flooding the East Helena Plant area, and evaluate impacts to the Prickly Pear Creek floodplain from construction of the dike or fill.



UPDATE TIME: 10:55AM
LT \HEL\020708\I:\Land Projects\705401\dwg\705401H009.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

3. Evaluate impacts to Prickly Pear Creek floodplain and the East Helena Plant resulting from removal of all or a portion of the dam that is generally referred to as the Smelter Dam, located at the east entrance to the plant.

1.1 HYDROLOGIC INVESTIGATION

The City of East Helena FIS and the Lewis and Clark County FIS list peak flood magnitudes on Prickly Pear Creek for various exceedance probabilities. These peak flows were used in the hydraulic analyses of the FIS to determine flood elevations and boundaries. Of particular interest is the magnitude corresponding to a one percent exceedance probability, which is commonly referred to as the 100-year flood, because the water-level elevations and floodplain boundaries from this flood are used to determine flood insurance rates and to regulate development restrictions along the creek. The two FIS's list the 100-year peak flood flow on Prickly Pear Creek to be 2,190 cubic feet per second (cfs) at East Helena, which is just downstream of the East Helena Plant. After first checking to verify that the peak flow magnitude is still valid in light of more recent data, a 100-year flood flow of 2,190 cfs was used in the hydraulic analysis of Prickly Pear Creek for this study.

To verify the flood magnitude estimate published in the FIS reports, which are over 20 years old, current flood magnitude estimates at the U.S. Geological Survey (USGS) streamflow gage near Clancy (Gage No. 06061500), which is upstream of East Helena, were compared to those from 1985. In both the East Helena and Lewis and Clark County FIS reports, the 100-year flood magnitude at Gage No. 06061500 was 1,805 cfs. The current USGS flood frequency estimate of the 100-year flood magnitude for the gage is 1,280 cfs (USGS, 2007). Since the current estimate of the 100-year flood magnitude is lower than the 1985 estimated magnitude, it is reasonable to conclude that use of the 2,190 cfs value from the FIS for East Helena is conservative and appropriate for use in this study.

1.2 HYDRAULIC ANALYSIS

1.2.1 Establishing Base Floodplain Conditions

The flood elevations and boundaries, shown on the FIRMs and FISs for Prickly Pear Creek, were derived from the results of hydraulic modeling conducted by Morrison-Maierle, Inc. in 1983. This modeling was completed using the U.S. Army Corps of Engineers computer program HEC-2 (USACOE, 1980), a step-backwater model. An electronic copy of the HEC-2 input model used for the 1983 study was obtained from Morrison-Maierle and imported into the HEC-RAS, River Analysis System (USACOE, 2005) hydraulic model, which is successor to HEC-2.

An initial HEC-RAS run with the imported HEC-2 data resulted in water surface elevations very close to those published in the FIS reports. Table 1-1 contains a comparison summary of the two sets of water surface elevations. Differences in water surface elevation are well within expected variations for this type of analysis, given the computational differences between HEC-2 and HEC-RAS.

In 2007, Hydrometrics surveyed new cross sections just upstream of the existing Smelter Dam structure at the plant's east entrance, along the east boundary of Lower Lake, and at a diversion structure approximately 1600 feet upstream of the east entrance, which is used to divert water into Upper Lake and possibly feed the Wilson Ditch. Elevations were referenced to the U.S. Geodetic Survey NGVD datum, which is consistent with the survey used for the 1985 FIS report. These new sections were used to refine the HEC-RAS model in the area along the east boundary to the Asarco East Helena Plant.

Table 1-2 contains results of the revised HEC-RAS model and provides a comparison to the previous results obtained using both HEC-RAS and HEC-2.

TABLE 1-1. HEC-RAS MODEL RESULTS WITH IMPORTED HEC-2 DATA FROM LEWIS & CLARK COUNTY AND EAST HELENA FISs – 100 YEAR DISCHARGE (2,190 cfs)

Jurisdiction	(1) FIS Station	(2) HEC-2 Station for FIS	(3) FIS Water Surface Elevation	(4) HEC-RAS River Station	(5) HEC-RAS Water Surface Elev. with Imported FIS HEC-2 Data	(5) – (3) Difference in Water Surface Elevations (feet)
Lewis & Clark Co.	--	78	--	33	3945.27	--
	BF	77	3934.2	32	3934.32	0.12
	BE	76	3928.1	31	3928.05	-0.05
	BD	75	3920.5	30	3920.58	0.08
City of E. Helena	--	74.1	--	29	3917.80	--
	O (east entrance Smelter Dam)	74	3917.4	28	3917.40	0
	P	73	3903.7	27	3903.79	0.09

Although the revised modeling analysis caused changes in some water surface elevations along the stream profile, the changes were largest in the upper reaches of the study area, away from the East Helena Plant. Near the plant, the largest change caused by the model revision was a 0.36 feet reduction in water surface elevation at the east entrance Smelter Dam (HEC-RAS model station 28). At this location (FIS station "O" and HEC-RAS station 28), a significant revision to the HEC-RAS model was made which altered the original HEC-2 model input data. At the Smelter Dam structure, the 1983 analysis calculated water surface elevations for corresponding discharges by assuming weir flow over the dam rather than using HEC-2 to calculate the depth of flow over the dam. The stage discharge relationship for the dam was then input as a water surface control into the HEC-2 model. Therefore, the output from the 1983 HEC-2 model reflects the stage discharge relationship that it was given, rather than a water surface elevation that it itself determined. The HEC-RAS model used for this study is much more robust than the HEC-2 model and can simulate flow at structures like the dam. Therefore in this analysis, the HEC-RAS model was allowed to calculate weir flow depths based on input of dam geometry and topographical data. With the addition of current survey data, this change to the analysis ensures that the new model is accounting for any changes to the topography near the dam that may have been made since 1983.

TABLE 1-2. SUMMARY OF HEC-RAS MODEL RESULTS WITH UPDATED AND CROSS SECTIONS – 100 YEAR DISCHARGE (2,190 CFS) PRICKLY PEAR CREEK AT ASARCO PLANT

Jurisdiction	(1) FIS Station	(2) HEC-2 Station for FIS	(3) FIS Water Surface Elevation	(4) HEC-RAS River Station	(5) HEC-RAS Water Surface Elev. with Imported FIS HEC-2 Data	(6) HEC-RAS Water Surface Elev. with Inserted and Updated Cross Sections	(6) – (5) Difference in Water Surface Elevations (feet)
Lewis & Clark Co.	--	78	--	33	3945.27	3944.59	-0.68
	BF	77	3934.2	32	3934.32	3934.79	0.47
	BE	76	3928.1	31	3928.05	3927.76	-0.29
	--	--	--	30.3	--	3921.06	--
	-- (Upper Lake diversion)	--	--	30.2	--	3920.99	--
	--	--	--	30.1	--	3920.98	--
	BD	75	3920.5	30	3920.58	3920.44	-0.14
	--	--	--	29.7	--	3919.27	--
City of E. Helena	--	--	--	29.6	--	3919.00	--
	--	--	--	29.4	--	3918.61	--
	--	--	--	29.2	--	3917.94	--
	--	74.1	--	29	3917.80	3917.88	0.08
	O (east entrance Smelter Dam)	74	3917.4	28	3917.40	3917.04	-0.36
	P	73	3903.7	27	3903.79	3903.79	0

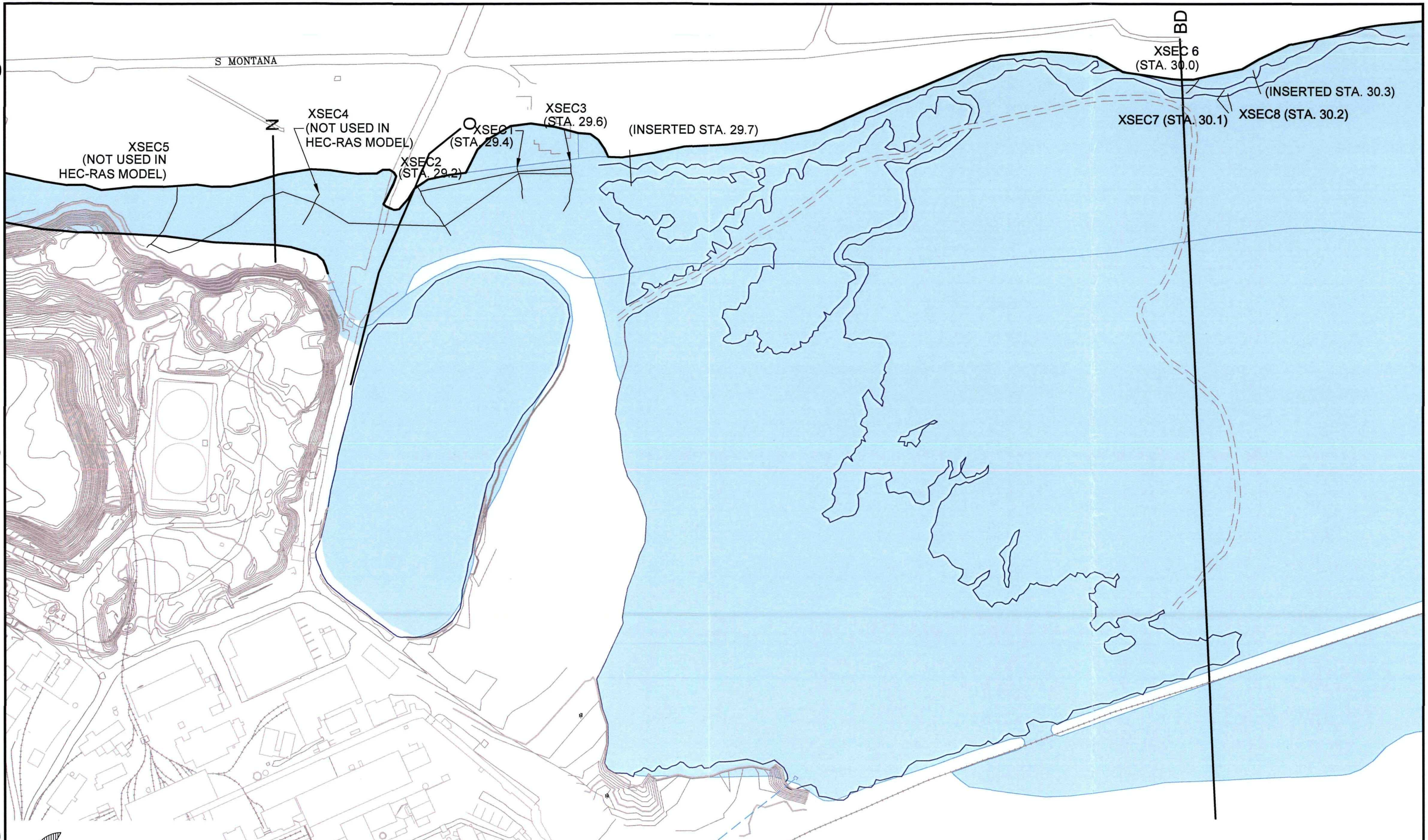
With the addition of cross sections upstream of the east entrance Smelter Dam structure, two notable changes to the floodplain boundaries occurred. First, the modeled water surface overtops a portion of the east bank of the stream valley, extending the flood boundary beyond the existing established floodplain to the east. Second, according to the model results, a significant portion of the ground separating Upper Lake and Lower Lake is not inundated by the 100-year flood. These modeling results provide supplemental information that was not included in the original FIS reports and provide new floodplain elevations and boundaries for use in this analysis as the base conditions to which impacts to the floodplain from proposed modifications of site grades will be compared. The changed floodplain boundaries and locations of inserted cross sections are shown as blue shading on Figure 1-2.

1.3 IMPACTS TO FLOODPLAIN ELEVATIONS AND BOUNDARIES WITH A PROPOSED BERM

A proposed berm to protect the smelter site from 100-year flood inundation is shown on Figure 1-3. Generally, the berm extends along the south and east sides of Lower Lake. To meet FEMA requirements for a flood-protection levee, preliminary design of the berm has the following specifications:

- Top elevation: 3922.3, which maintains a minimum of 3 feet of freeboard above the highest 100-year flood elevation along the berm.
- Top width: 10 feet, which is required to accommodate maintenance vehicles.
- Side slopes: 3 (horizontal) to 1 (vertical).

The HEC-RAS model results that reflect the addition of the berm are summarized in Table 1-3. The largest increase in flood elevation is 0.34 feet in the area of the berm. The floodplain boundary conditions with a berm in place are very nearly the same as the boundaries shown on Figure 1-2, except that Lower Lake is protected from flooding, removing it from the 100-year floodplain. Even though it appears the ground between Upper Lake and Lower Lake is higher than the 100-year flood level of Prickly Pear Creek, the proposed berm is shown on this portion of ground in order to develop a factor of safety for



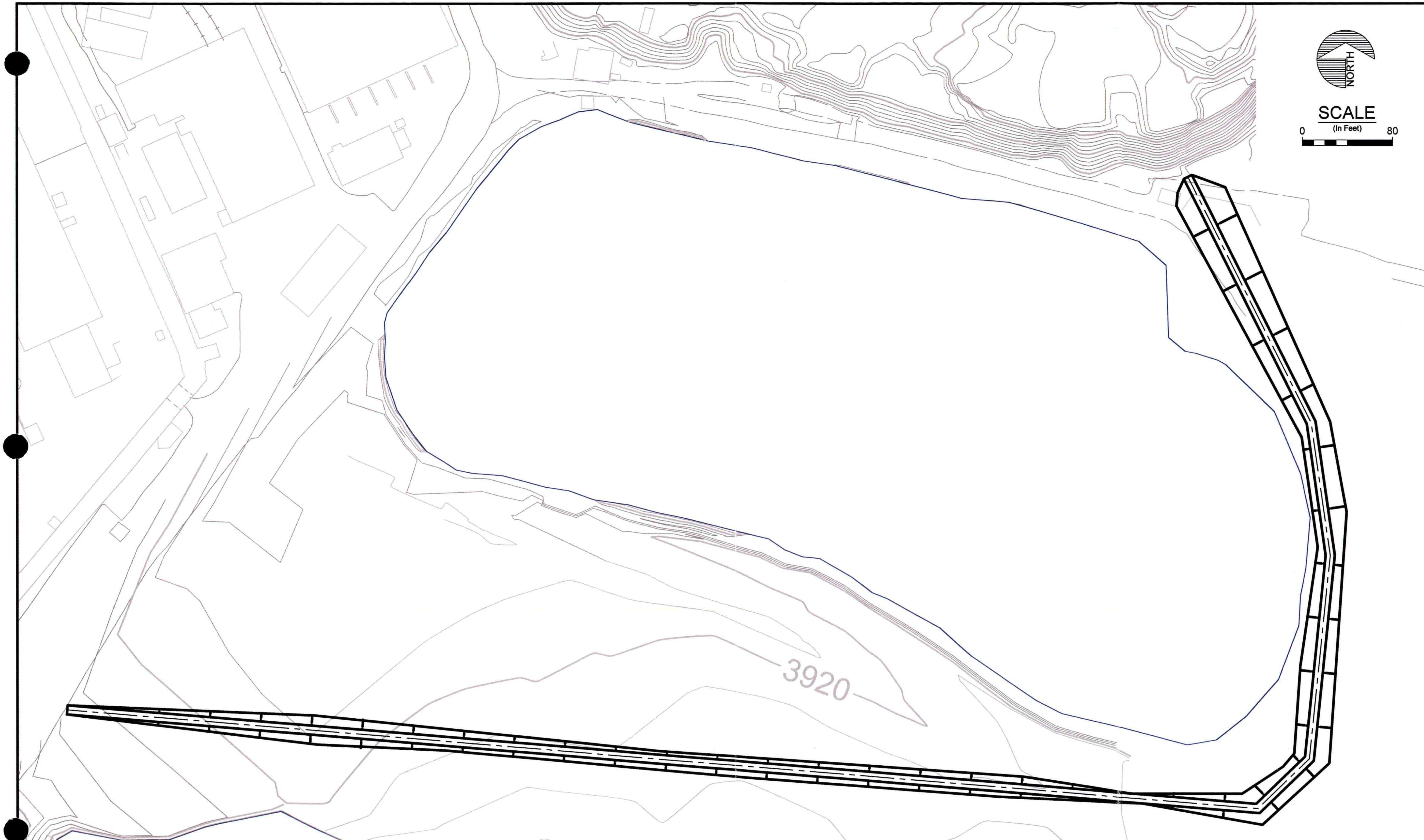
FLOOD ANALYSIS FOR PRICKLY PEAR CREEK
EAST HELENA SMELTER

**PRICKLY PEAR CREEK
UPDATED FLOODPLAIN
BOUNDARIES WITH INSERTED
CROSS SECTIONS**

FIGURE
1-2

UPDATE TIME: 9:58AM
LT \HEL\020708\I:\Land Projects\705401\dwg\705401H0011.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers



FLOOD ANALYSIS FOR PRICKLY PEAR CREEK
EAST HELENA SMELTER

PROPOSED BERM AROUND LOWER LAKE

FIGURE
1-3

UPDATE TIME: 10:47AM
LT \HEL\020708\I:\Land Projects\705401\dwg\705401H0017.dwg

Hydrometrics, Inc.
Consulting Scientists and Engineers

TABLE 1-3. SUMMARY OF HEC-RAS MODEL RESULTS WITH ADDITION OF BERM – 100 YEAR DISCHARGE (2,190 cfs) PRICKLY PEAR CREEK AT ASARCO PLANT

Jurisdiction	(1) FIS Station	(2) HEC-2 Station for FIS	(3) FIS Water Surface Elevation	(4) HEC-RAS River Station	(5) HEC-RAS Water Surface Elev. with Inserted and Updated Cross Sections	(6) HEC-RAS Water Surface Elev. with Proposed Berm Added	(6) – (5) Difference in Water Surface Elevations (feet)
Lewis & Clark Co.	--	78	--	33	3944.59	3944.59	0
	BF	77	3934.2	32	3934.79	3934.79	0
	BE	76	3928.1	31	3927.76	3927.76	0
	--	--	--	30.3	3921.06	3921.06	0
	-- (Upper Lake diversion)	--	--	30.2	3920.99	3920.99	0
	--	--	--	30.1	3920.98	3920.98	0
	BD	75	3920.5	30	3920.44	3920.44	0
	--	--	--	29.7	3919.27	3919.34	0.07
City of E. Helena	--	--	--	29.6	3919.00	3919.09	0.09
	--	--	--	29.4	3918.61	3918.82	0.21
	--	--	--	29.2	3917.94	3918.25	0.31
	--	74.1	--	29	3917.88	3918.02	0.14
	O (east entrance Smelter Dam)	74	3917.4	28	3917.04	3917.08	0.04
	P	73	3903.7	27	3903.79	3903.79	0

flood protection by providing the FEMA required 3 feet of freeboard above the 100-year flood level.

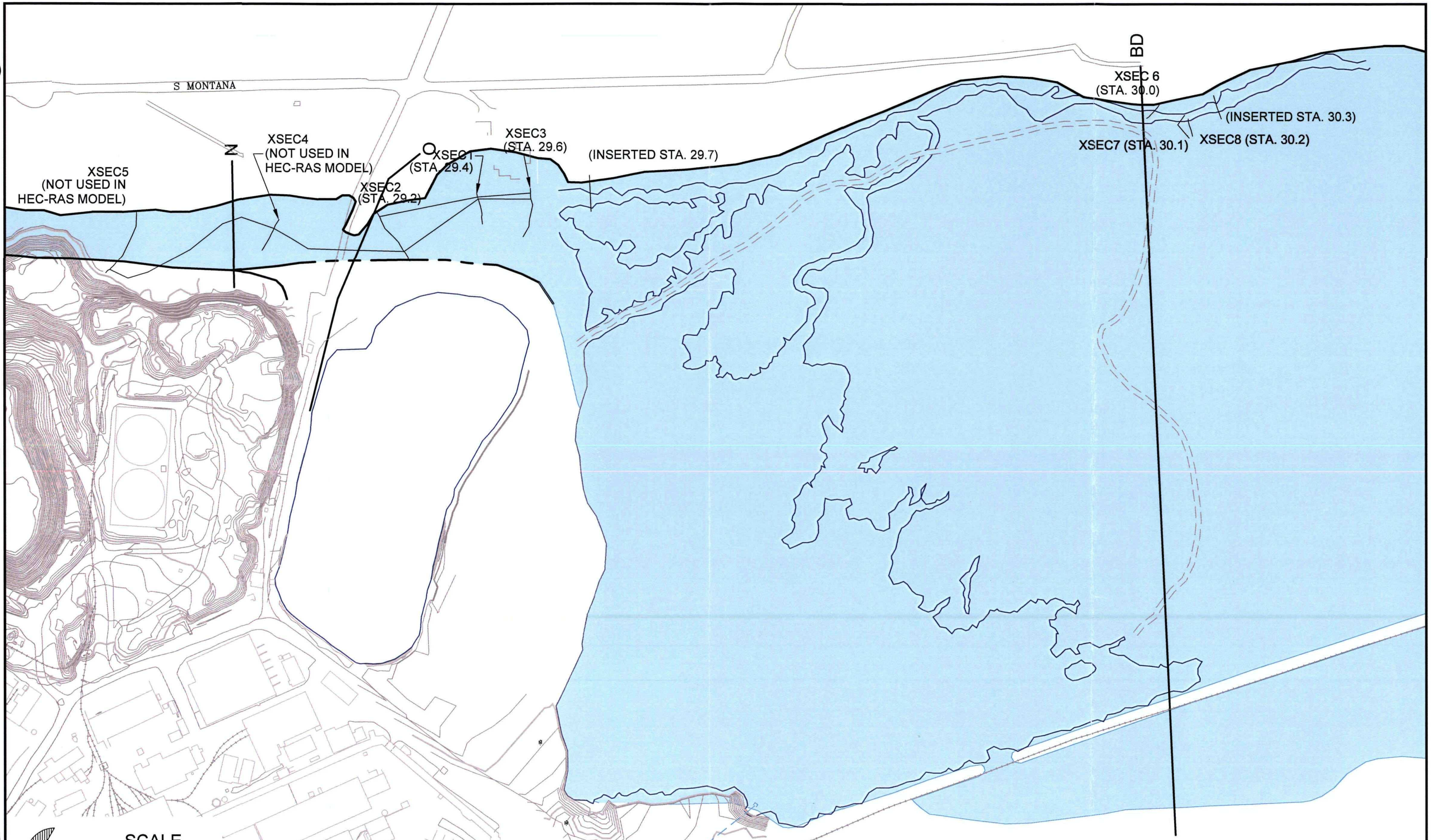
The flood fringe is that area between the floodway boundary and the edge of the floodplain. According to state floodplain management rules (ARM 36.15.701), the maximum allowable increase above the designated 100-year flood elevation due to development in the flood fringe is 0.5 feet. Therefore, construction of the proposed berm within the flood fringe appears to be an allowable, permitted use in the floodplain. However, from the existing floodplain and floodway regulatory maps, it appears the proposed berm on the east side of Lower Lake encroaches into the designated floodway. This may pose a problem because state floodplain management rules do not include flood berms or dikes as an allowable use within the floodway. This issue as well as other considerations for building a berm are discussed in the section of this report titled Issues Related to Construction of a Flood-Protection Berm.

1.3.1 Impacts to Floodplain Elevations and Boundaries with Entire Removal of the East Entrance Smelter Dam

Another potential option for eliminating flood potential at the smelter site is to remove all or part of the existing dam at the east entrance to the smelter. Removal of the entire dam would entail not only removal of the dam but considerable regrading and reconstruction of the stream for approximately 1000 to 1500 linear feet upstream, because the upstream stream bottom grade is approximately 10 feet higher than the downstream grade at the dam. Table 1-4 summarizes the effects on flood elevations of removing the entire structure. Figure 1-4 shows impacts to the 100-year floodplain from the entire removal of the dam structure. The modeled flood elevations are considerably lower than the base condition and would eliminate the potential for flooding the East Helena Plant. Considerations for removing the entire structure are discussed in the section of this report titled Issues Related to Removal of the Entire Smelter Dam.

TABLE 1-4. SUMMARY OF HEC-RAS MODEL RESULTS WITH ENTIRE DAM REMOVED – 100 YEAR DISCHARGE (2,190 cfs) PRICKLY PEAR CREEK AT ASARCO PLANT

Jurisdiction	(1) FIS Station	(2) HEC-2 Station for FIS	(3) FIS Water Surface Elevation	(4) HEC-RAS River Station	(5) HEC-RAS Water Surface Elev. with Inserted and Updated Cross Sections	(6) HEC-RAS Water Surface Elev. with Smelter Dam Removed	(6) – (5) Difference in Water Surface Elevation (feet)
Lewis & Clark Co.	--	78	--	33	3945.59	3945.58	-0.01
	BF	77	3934.2	32	3934.79	3934.80	0.01
	BE	76	3928.1	31	3927.76	3927.75	-0.01
	--	--	--	30.3	3921.06	3921.05	-0.01
	-- (Upper Lake diversion)	--	--	30.2	3920.99	3920.99	0
	--	--	--	30.1	3920.98	3920.98	0
	BD	75	3920.5	30	3920.44	3920.51	0.07
	--	--	--	29.7	3919.27	3916.82	-2.45
City of E. Helena	--	--	--	29.6	3919.00	3913.51	-5.49
	--	--	--	29.4	3918.61	3912.60	-6.01
	--	--	--	29.2	3917.94	3911.08	-6.86
	--	74.1	--	29	3917.88	---	---
	O (east entrance Smelter Dam)	74	3917.4	28	3917.04	3908.29	-8.75
	P	73	3903.7	27	3903.79	3903.79	0



FLOOD ANALYSIS FOR PRICKLY PEAR CREEK
EAST HELENA SMELTER

PRICKLY PEAR CREEK
FLOODPLAIN MODIFICATIONS WITH
ENTIRE DIVERSION DAM
REMOVED

FIGURE
1-4

Hydrometrics, Inc.
Consulting Scientists and Engineers

1.3.2 Impacts to Floodplain Elevations and Boundaries with Partial Removal of the East Entrance Smelter Dam

If only part of the Smelter Dam structure were to be removed, it may be possible to create a much larger flow area for passing the flood while maintaining a stable base for controlling erosion at the dam structure. This approach could eliminate the need for regrading the stream upstream of the Smelter Dam. It would also lower the flood elevations upstream of the dam and eliminate the need for a berm or other flood protection structures at the smelter site. This option is based on removal of the portion of the dam above the current spillway level. The abutment areas would also be sloped back a considerable distance to open as much flow area as practical. All excavated surfaces would require armoring to prevent erosion during flood flows. A structural analysis of the dam would be necessary to determine if the structure could be modified and yet remain structurally sound. The effects of removing part of the dam on flood elevations are summarized in Table 1-5. Floodplain impacts for this scenario would be very similar to the boundaries shown on Figure 1-4. Considerations for removing part of the structure are discussed in the section of this report titled Issues Related to Partial Removal of the Smelter Dam.

1.3.3 Issues Related to Construction of a Flood-Protection Berm

The current state floodplain management regulations for construction and maintenance of a flood-protection berm (or levee) are somewhat prohibitive for application at the East Helena Plant. There are two major issues associated with berm construction:

1. The berm would be located in the designated floodway, which is a use prohibited by the current regulations (ARM 36.15.605). This may be addressed by relocating the berm out of the floodway by filling in a portion of Lower Lake or by applying for a variance. Any impacts caused by having the berm in the floodway, such as a floodway adjustment and increased flood elevations, are confined to property owned by ASARCO, which would be a compelling argument for the variance.

TABLE 1-5. SUMMARY OF HEC-RAS MODEL RESULTS WITH PARTIAL DAM REMOVED – 100 YEAR DISCHARGE (2,190 cfs) PRICKLY PEAR CREEK AT ASARCO PLANT

Jurisdiction	(1) FIS Station	(2) HEC-2 Station for FIS	(3) FIS Water Surface Elevation	(4) HEC-RAS River Station	(5) HEC-RAS Water Surface Elev. with Inserted and Updated Cross Sections	(6) HEC-RAS Water Surface Elev. with Partial Smelter Dam Removed	(6) – (5) Difference in Water Surface Elevation (feet)
Lewis & Clark Co.	--	78	--	33	3945.59	3944.59	0
	BF	77	3934.2	32	3934.79	3934.79	0
	BE	76	3928.1	31	3927.76	3927.76	0
	--	--	--	30.3	3921.06	3921.06	0
	--	--	--	30.2	3920.99	3920.99	0
	--	--	--	30.1	3920.98	3920.98	0
	BD	75	3920.5	30	3920.44	3920.44	0
	--	--	--	29.7	3919.27	3919.01	-0.26
City of E. Helena	--	--	--	29.6	3919.00	3918.67	-0.33
	--	--	--	29.4	3918.61	3918.14	-0.47
	--	--	--	29.2	3917.94	3916.74	-1.20
	--	74.1	--	29	3917.88	3914.96	-2.92
	O	74	3917.4	28	3917.04	3906.21	-10.83
	P	73	3903.7	27	3903.79	3903.79	0

2. Current regulations state that a flood protection berm must be owned by a public entity and have operation and maintenance procedures established to assure proper maintenance for perpetuity (ARM 36.15.505 and 36.15.606). ASARCO may have to obtain or form a publicly-owned sponsor for the berm with the understanding that perpetual maintenance would be an integral part of ownership.

Another option for flood protection at the East Helena Plant would be to place fill in the flood fringe area as part of the overall capping plan for the site. Fill would have to be placed to an elevation that allows at least some freeboard above the maximum 100-year flood elevation. This option would eliminate the need for having public ownership. It is important that the fill is not located in the floodway in order to avoid the issues discussed above.

1.3.4 Issues Related to Removal of the Entire Smelter Dam

Removal of the dam at the east entrance to the smelter would succeed in eliminating threat of damage from the 100-year flood to the smelter site. This option would require lowering the stream bed nearly 10 feet at the dam location and regrading and reconstructing the stream approximately 1000 to 1500 feet upstream to avoid uncontrolled degradation of the stream channel. The intention of this option would be to keep the Upper Lake diversion intact and to regrade the stream no further upstream than the Upper Lake diversion structure. However this option would involve significant excavation of material and intensive stream reconstruction to maintain a viable and stable stream channel.

A benefit to removing the structure would be to enhance the stream as a fishery and to eliminate a fish barrier. There may be Montana Department of Fish, Wildlife and Parks funding to assist in improving fish and aquatic habitat.

Removal of the structure would also remove access to the site from the east side.

1.3.5 Issues Related to Partial Removal of the Smelter Dam

If only the upper part of the east entrance dam were removed, the stream channel could remain at its current grade and location. Removing the upper part of the structure would open up a significant flow area and lower the 100-year flood elevations to levels that would not impact the smelter site. Although a thorough structural evaluation is needed to determine if the lower part of the structure will be stable when standing alone, this option does not require excavation of the streambed upstream of the dam. However, it does eliminate the east entrance to the smelter and considerable excavation in the dam abutment areas would be necessary to slope back and open the flow area to the most practicable extent.

2.0 SUMMARY

In summary, there are a number of options for preventing the 100-year flood of Prickly Pear Creek from flooding the East Helena Plant site. However, there are limitations to building a protective dike, such as regulatory barriers to building in the designated floodway and the criteria for public ownership. Removing the entire east-entrance dam structure also presents problems with implementation because of significant stream regrading and reconstruction.

At this time, partial removal of the east entrance dam structure appears to be the most straight forward alternative and will likely be the least costly. This alternative would require removal of the upper part of the structure, which includes the road deck and the gates and support structures. The bottom portion of the structure would remain in place. This option has considerable advantages over the other alternatives considered in this report. It appears to reduce the 100-year flood elevations in the area of the East Helena Plant to levels where a dike or additional fill may not be necessary to protect the plant from flooding. It will also maintain the stream grade at current levels which will eliminate the need to significantly regrade the stream, as was proposed for entire removal of the structure.

The most significant disadvantage to the partial removal alternative is that it would eliminate the east entrance to the plant. This may not be critical after plant closure, but it will limit access to the site.

As-built drawings of the existing dam structure were located in ASARCO files. A general description of partial removal of the structure is included as Appendix A to this report. If this option is selected as the preferred alternative, Hydrometrics will prepare designs for removal of the top of the structure. The design effort would produce contract documents for construction. Engineering oversight and contract administration would be needed during construction.

3.0 REFERENCES

Federal Emergency Management Agency, 1985. Flood Insurance Study, City of East Helena, Montana, Lewis and Clark County. September 27.

Federal Emergency Management Agency, Revised 2002. Flood Insurance Study, Lewis and Clark County, Montana, Unincorporated Areas. June 17.

U.S. Department of the Army, Corps of Engineers, 1980. HEC-2 Water Surface Profiles, Generalized Computer Program. Hydrologic Engineering Center, Davis, California. April.

U.S. Department of the Army, Corps of Engineers, 2005. HEC-RAS River Analysis System, Generalized Computer Program. Hydrologic Engineering Center, Davis, California. May.

U.S. Geological Survey, 2007. Montana Flood-Frequency and Basin-Characteristic Data. Web site http://mt.water.usgs.gov/freq?page_type=site&site_no=06061500.

APPENDIX A

CONCEPTUAL WORK DESCRIPTION FOR PARTIAL REMOVAL OF SMELTER DAM

CONCEPTUAL WORK DESCRIPTION FOR
PARTIAL REMOVAL OF SMELTER DAM

The work described below is conceptual in nature and is based on site visits and available as-built drawing review. Intent of the work is to remove the upper portion of the Smelter Dam to provide additional flood flow capacity to reduce the chance of flooding on the remediated smelter property. Removal would include interior wood bridge decking and supports and concrete piers and walls to the spillway crest, which is shown as elevation 3912.3 on the as-built drawings. The abutment piers on the west and east sides of the spillway would remain in place. The following is a general description of the work:

General Description of Work

1. Remove and relocate or abandon two utility pipelines on the bridge and piers. One is the green steel oxygen pipe on the upstream side of the bridge and the other is an insulated metal pipe line (possibly natural gas) on the downstream side of the structure. Coordination with utility owners is needed.

2. Remove two (2) gate operators from the gate structure. Determine if operators can be reused or refurbished. If not, purchase two new operators to replace existing ones. Remove operator supports. Remove stems and guides down to the elevation of the spillway crest (elevation 3912.3 on the drawings).

3. Cut off the steel trashrack for the gate structure down to the spillway crest elevation.

4. Remove timber bridge decking, support beams, fencing and safety rails.

5. Remove two (2) interior timber piers and one (1) timber support brace in the gate structure.

6. Remove upper portions of two (2) interior concrete piers and the upstream concrete wall of the gate structure down to the crest of the spillway. Also, remove the exterior concrete abutment walls down to the crest of the spillway. Slope back the abutment areas

approximately 90 feet on the west side and approximately 50 feet on the east side to open up the flow area. The excavated abutments will be armored with riprap or other armoring material to prevent erosion.

7. Patch and/or cover with concrete the tops of the cut off concrete piers and wall to cover exposed rebar and create smooth surfaces.

8. Construct new gate operator supports. Remount existing or install new operators. Install new stem guides. Install new stems and splice to the existing lower stem.

9. Construct new upper portion of the steel trashrack and weld to the existing lower portion. Connect new upper portion to the gate structure wall or the new operator supports.

10. Install new fencing and traffic barriers.

Reference Drawings

Drawing No. 4316, Smelter Lake Dam 1948 Reconstruction of Gates, American Smelting and Refining Company, 1948, Revised 1981.

Drawing No. 5236, Wood Bridge Over Smelter Dam 1961 Reconstruction, American Smelting and Refining Company, 1961.

Drawing No. 5517, Wood Bridge Over Smelter Dam 1965 Alterations, American Smelting and Refining Company, 1965.

Drawing No. 7087, ASARCO Smelter Dam Repair, Morrison-Maierle, Inc., 1981.